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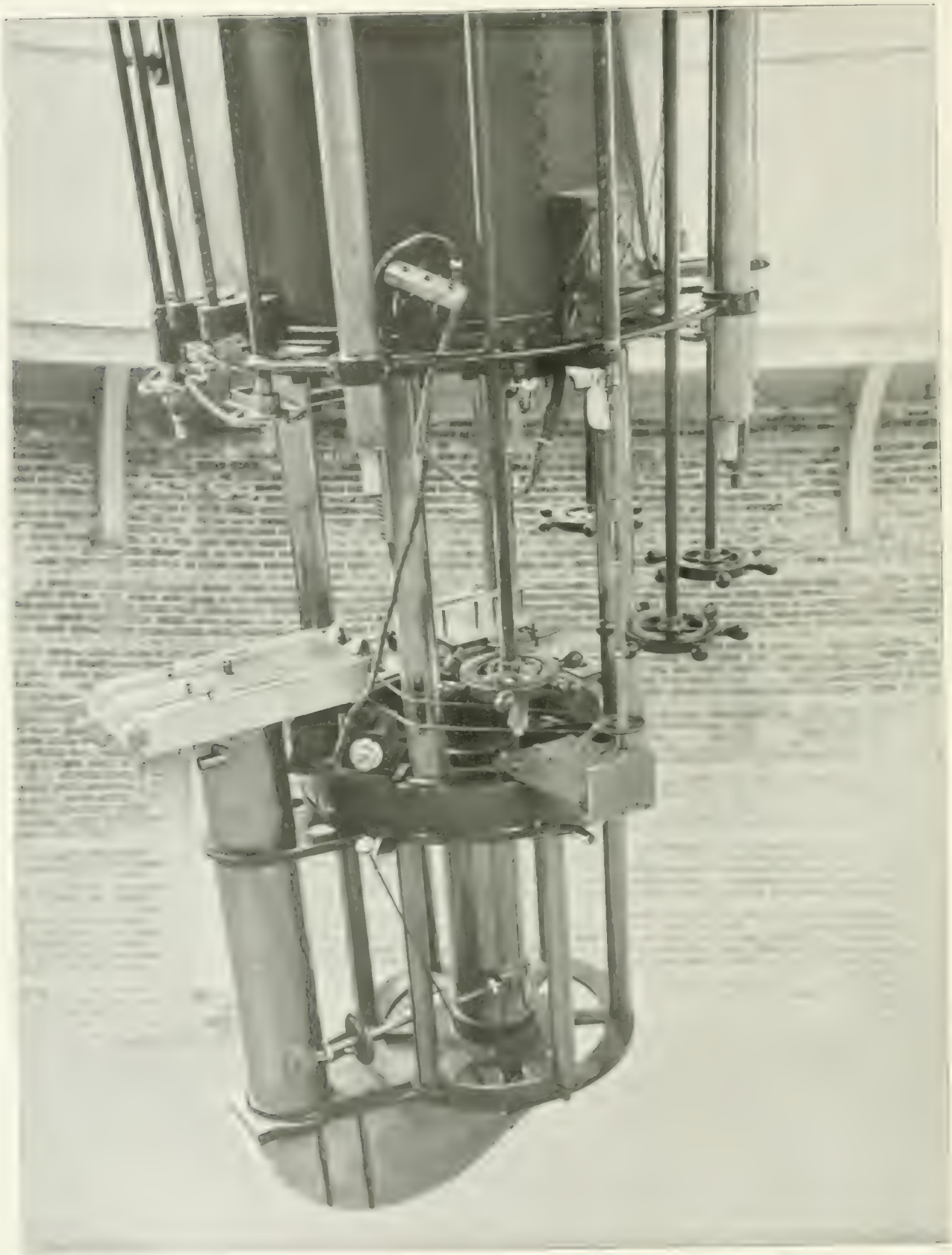

THE BEARDSLEY PHOTOHELIOGRAPH ATTACHED TO THE 40 INCH YERKES REFRACTOR

THE UNIVERSITY OF CHICAGO
FOUNDED BY JOHN D. ROCKEFELLER

PUBLICATIONS OF THE YERKES OBSERVATORY

VOLUME III PART I

THE RUMFORD SPECTROHELIOGRAPH OF THE YERKES OBSERVATORY

BY

GEORGE E. HALE
AND
FERDINAND ELLERMAN

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THE RUMFORD SPECTROHELIOGRAPH OF THE YERKES OBSERVATORY

By George E. Hale and Ferdinand Ellerman[1]

INTRODUCTION

The application of the spectroscope in 1868 to the observation of solar prominences in full sunlight opened an extensive field of research, and directed the attention of astronomers to the importance of applying the powerful instruments and methods of the physical laboratory to the study of the Sun. Since that time the rise and development of stellar spectroscopy have further emphasized the importance of solar investigation. For it cannot be too often repeated that the Sun is the only star whose phenomena can be studied in detail; in interpreting the spectroscopic phenomena of all the other stars we must therefore return in every instance to the Sun. If its infinitely varied and complex activities were well understood, the problems encountered in the study of stellar evolution would be greatly simplified. But although the constant use of the spectroscope, dating back to the discovery of the chemical constitution of the Sun in 1859, has furnished an immense amount of valuable information, there appears to be an exceptional opportunity at the present time to secure new and important results, especially through the use of the large spectroscopes and other powerful instruments of the physical laboratory. For solar spectroscopy has by no means kept pace with laboratory spectroscopy; few large grating spectroscopes, such as are found in every physical laboratory, have ever been employed to study a large image of the Sun. This being true, it is less remarkable that other laboratory instruments, not so generally available, are still awaiting application in solar research.

The widespread interest in total solar eclipses, and the great expenditure of time and money so freely made in observing them, surely tend to emphasize what has been said. For if it is worth while (as it certainly is) to travel thousands of miles, and to undergo hardships, in order to spend a few flying seconds in making observations, it would seem no less advantageous to continue solar work at home, where entirely new phenomena can be observed daily with a much smaller expenditure of effort. Total eclipses of the Sun will always be of great importance, as the corona cannot be observed in full sunlight. But the study of many other solar phenomena, which can be observed whenever the sky is clear, is quite as likely to advance our knowledge of the solar constitution.

It was with some such ideas in mind that the work of the Kenwood Observatory was undertaken in 1888. It seemed obvious that even a very slight appreciation of the subject should suffice to render possible some improvements of method. A first step in this direction was attempted by the invention of the spectroheliograph in 1889. The original purpose of this instrument was the photography of the chromosphere and prominences, in order to simplify and render more accurate the daily delineation of their form. It was subsequently found, as will be shown in the present paper, that the instrument had a far wider range of application, and that it could be applied in directions which had not suggested themselves in 1889.

The principle of the spectroheliograph is exceedingly simple. Imagine a direct-vision spectroscope in which the eyepiece ordinarily employed is replaced by a (second) slit. If an image of the Sun is formed on the first slit of this spectroscope, the second slit will permit the passage of only a narrow region of the spectrum corresponding in width to this slit. If the slit is now moved until it

[1] Although this paper has been written by myself, for convenience of reference to previous studies and opinions, it belongs also to Mr. Ellerman, because of his important share in the work.—G. E. H.

coincides with the *HB* line, for example, only hydrogen light will pass through the instrument. If, then, a photographic plate is placed behind and almost in contact with the second slit, and the spectroscope is moved at right angles to its optical axis, an image of the Sun, in monochromatic hydrogen light, will be built up on the plate from the successive images of the slit. If the exposure is suitable, the chromosphere and prominences will be shown surrounding this image.

Such is the spectroheliograph in its simplest form. It is obviously immaterial whether the motion be given to the spectroscope, on the one hand, or to the solar image and photographic plate, on the other. It is only necessary that the relative motion of the solar image and first slit be such that light from all parts of the solar disk shall pass successively through the slit, while the photographic plate and second slit experience a corresponding relative motion. The second slit serves simply to isolate any desired line in the spectrum; hence its width must be such as exactly to include this line, and to exclude all light from other parts of the spectrum. It is evident that the spectroheliograph may be considered simply as a form of monochromatic exposing shutter, differing from the ordinary focal plane shutter only through the use of a narrower exposing slit, and the inclusion of an optical train which limits the light to a single line in the spectrum.

Although this idea suggested itself to me quite independently in 1889, I subsequently learned that the principle was by no means new. Indeed, Janssen had suggested it as early as 1869, while Braun, of Kalocsa, and Lohse, of Potsdam, had designed instruments involving the same principle in 1872 and 1880 respectively. Indeed, Lohse had constructed and experimented with the instrument he designed, but his work was not successful. This may have been due in part to the fact that the hydrogen line which he employed is not nearly so well adapted for prominence photography as are the H and K lines of calcium. This was one of the difficulties experienced in my first (unsuccessful) experiments, which, through the kindness of Professor Pickering, were made at the Harvard College Observatory in the winter of 1889–90.

In April, 1891, after the Kenwood Observatory had been equipped with a twelve-inch equatorial refractor and a powerful solar spectroscope, a photographic study of the ultra-violet spectrum of the chromosphere and prominences was undertaken in the hope of finding lines better adapted than those of hydrogen for the photography of the prominences. The brilliant H and K lines of calcium, previously observed visually in full sunlight by Professor Young and photographically at total eclipses, were found in all cases to be the most conspicuous lines in the spectrum of the chromosphere and prominences. The remarkable brightness of these lines, and more particularly their position at the center of the broad dark shades due to the denser calcium vapor in the lower portion of the solar atmosphere, render them peculiarly well adapted for the purposes of prominence photography. Indeed, it was possible with their aid to obtain good photographs of single prominences merely by opening the slit of the spectroscope to such an extent as to include a considerable part of the prominence, and giving a very short exposure to the image formed directly upon a photographic plate. But this method was too limited to be of general application. In order to record photographically the entire circumference of the Sun, with the chromosphere and prominences, it was necessary to employ the principle of the spectroheliograph, involving the use of narrow slits, moved with reference to the solar image and photographic plate. The first successful spectroheliograph was brought into use at the Kenwood Observatory in January, 1892. After this time it was employed regularly on every [illegible] which the instruments of the Kenwood Observatory were removed to the Yerkes Observatory.

My spectroscopic studies of the Sun during the spring and summer of 1891 were not confined to the chromosphere and prominences. It was soon found that the H and K lines, previously recognized as [illegible] of the prominences [illegible] the hydrogen lines themselves, were reversed [illegible] to exist in regions surrounding the solar disk. This fact had not escaped the attention of Professor Young, who had long before announced the presence of these lines in the neighborhood

of active Sun-spots. But the greater delicacy of the photographic process showed these bright lines to characterize very extensive regions on the Sun's surface, not confined to the immediate neighborhood of spots, but scattered throughout the Sun-spot zones, and even extending from pole to pole. It was noticed from the outset that these bright regions corresponded closely with the well-known faculæ, and in my earlier work they were called by this name. It has since become clear, however, that a distinctive term should be adopted, and I now propose the name *flocculi* for the regions on the Sun's disk which are shown only on photographs made with the spectroheliograph (see p. 14).

The possibility of photographing these bright regions on the Sun's disk with the spectroheliograph at once greatly extended the range of that instrument, as it was thus shown to be capable of recording, not only the prominences, which could be observed, though very laboriously, by visual methods, but also extensive and important phenomena invisible to the eye and not shown on photographs taken in the ordinary manner. Spectroheliographs were accordingly adopted for use at other observatories, first by Mr. Evershed in England, and subsequently (in 1893) by M. Deslandres at the Paris Observatory. Both of these spectroscopists introduced modifications and improvements of the instrument—Mr. Evershed constructing a direct-vision spectroheliograph of remarkable simplicity and beauty, and M. Deslandres, with a different type of instrument, obtaining photographs of great excellence.

Certain defects of construction in the Kenwood spectroheliograph, which nevertheless did not prevent it from yielding some thousands of photographs of prominences and calcium flocculi, were incident to the circumstances which governed the design of the instrument. For the earlier experiments in solar-prominence photography, a large plane grating spectroscope had been constructed, with collimator and observing telescope rigidly fixed at an angle of twenty-five degrees. The simplest and best form of spectroheliograph, first illustrated by the instrument used in my experiments on Mount Etna in 1894,[2] is that in which the whole instrument moves as a single structure, the solar image and photographic plate being fixed in position. The large size of the Kenwood solar spectroscope, and the necessity of attaching it rigidly and without means of motion to the twelve-inch refractor, precluded the possibility of employing this principle. It was accordingly decided to adopt, as the best means available under the circumstances, a pair of moving slits, one at the extremity of the collimator, the other at the end of the observing telescope, immediately in front of the photographic plate. Thus while the first slit was moved (by hydraulic power) across the fixed solar image, the second slit, connected with the first slit by a system of levers, was moved with the spectrum at such a rate that the K line continued to pass through it, building up a monochromatic image of the Sun on the photographic plate. It is obvious that under these circumstances the motion of the K line (usually in the fourth-order spectrum) would not have the same velocity as the first slit. This resulted in a compression of the solar image, afterward eliminated by a simultaneous motion of the photographic plate, which was displaced during the exposure by an amount equal to the difference between the long and short axes of the oval image of the Sun.

It had been hoped and expected that the interruption in the daily series of photographs caused by removal to the Yerkes Observatory in 1896 would be of short duration; but unfortunately this did not prove to be the case. The twelve-inch refractor, devoted at Kenwood entirely to solar work, was needed at the Yerkes Observatory for general purposes. It therefore became necessary to remove the spectroheliograph from this telescope, and to modify the mounting in order to adapt it for general observational work. The spectroheliograph was remodeled for use with the forty-inch refractor as a solar spectroscope, and it was expected that a new spectroheliograph, large enough to photograph the seven-inch (17.8 cm) image at the focus of this telescope, would soon be ready for use. But the funds required for the construction of the new spectroheliograph were not forthcoming, and when it finally became possible to undertake work on this instrument (through a grant from the Rumford

[2] *Astronomy and Astrophysics*, 1894.

from [illegible] the gifts of friends of the Observatory) progress was slow, owing to the limited funds available. [illegible] seven-inch solar image, collimator and camera lenses of about ten inches (25.4 cm) aperture were wanted, but the considerable cost of such lenses rendered their purchase impossible, and a pair of 6¼-inch (15.7 cm) Voigtländer portrait lenses, obtained from second-hand dealers after a year's search, were adopted. With lenses of this aperture it is evident that much light must be lost at the extremities of the slit, and that the resulting image of the Sun must therefore be deficient in brightness at the corresponding limbs. Even after the lenses had been secured, the demands of other phases of the Observatory's work greatly retarded the construction of the instrument, and it was not until the latter part of 1899 that it was ready for trial.

THE RUMFORD SPECTROHELIOGRAPH[3]

The design finally adopted was reached only after long and careful consideration of the special conditions of the problem. As has already been stated, the ideal form of spectroheliograph is that in which the instrument is moved as a whole, while the image of the Sun and the photographic plate are stationary. It was impossible, however, to use an instrument of this kind with the forty-inch refractor, as the great weight of the moving parts would have thrown the telescope into vibration, thus preventing good images from being obtained. The only feasible solution of the problem seemed to require that the motion of the Sun's image across the first slit be produced by a uniform motion of the telescope tube in right ascension or declination, the photographic plate being moved at the same time across the second slit. The obvious mechanical difficulties of carrying this plan into effect with a telescope sixty-four feet (19.5 m) in length were not overlooked at the time, but it seemed necessary to meet these difficulties and to endeavor to overcome them by the best means at command. The slow-motion electric motors provided by Messrs. Warner & Swasey could evidently be adapted to produce the necessary motion of the solar image and plate. For certain reasons it would have been preferable to move the instrument in right ascension. But the necessity of connecting the photographic plate directly with the slow-motion motor led to the choice of the declination motor, as this is mounted on the tube in such a position that a shaft could be run from it to the lower end of the telescope, while the right-ascension motor is mounted on the declination sleeve, at a considerable distance from the telescope tube. It would therefore be difficult to connect it in any simple way with the screws which drive the plate-carriage.

A photograph of the spectroheliograph is reproduced in Plate I. It will be seen that it consists essentially of a heavy circular iron casting, below which extends a skeleton frame, which supports the collimator and camera tubes and the cast-iron bracket that forms the base of the prism box. When in use on the telescope the instrument is borne by the large ring, supported by four tubes, which is used to carry all of the spectroscopes and other heavy attachments employed with the forty-inch refractor. This ring can be racked in and out along the axis of the telescope, thus permitting the first slit of the spectroheliograph to be set in the focal plane of the forty-inch objective corresponding to light of any desired wave-length.

Slits.—The two slits of the spectroheliograph are each eight inches long, curved as described below. The first slit is of very simple construction, one jaw being fixed, the other movable by a micrometer screw. The jaws are of brass, nickel plated and polished so as to reduce the heating by the Sun, which is very great on account of the large diameter of the image. In the first experiments with the instrument it was found that as the Sun moved slowly across the slit the heating of the jaws caused them to come together along the central part of the slit, thus cutting off the light from parts of the plate during the exposure. This difficulty was remedied by mounting a light metallic screen, pierced by a long narrow window, a short distance in front of the slit.

During the long exposures required in photographing the chromosphere and prominences at the limb, it is desirable to exclude the direct light of the Sun's disk from the collimator. With such an instrument as the Kenwood spectroheliograph, where the image of the Sun is fixed with reference to the collimator, this can be done very simply by means of a metallic disk, slightly smaller in diameter than the Sun's image, supported directly in front of the slit. In the Rumford spectroheliograph, however, the Sun's image moves across the slit during the exposure. For this reason the occulting disk must be moved during the exposure at the same rate as the Sun's image. This is accomplished by mounting the disk on a light carriage, which moves a little above the first slit. The motion of this carriage is produced by a rod connecting it with the plate-carriage, which moves behind the second slit and contains the photographic plate. The length of the arm connecting the two carriages can be varied by means of a rack and pinion, thus permitting the Sun's image to be kept central on the disk, even if there is some drift of the image (due to imperfect adjustment of the driving-clock) during a long exposure.

The second slit is similar to the first slit, but additional adjustments are provided. As in the case of the first slit, one jaw is fixed, while the other is opened by means of a micrometer screw, so extended that its divided head projects from the end of the light-tight box in which the plate-carriage slides. A second screw, also provided with a graduated head, permits the second slit as a whole to be moved parallel to itself. This greatly facilitates the setting on the spectral lines, which is accomplished in the manner described below.

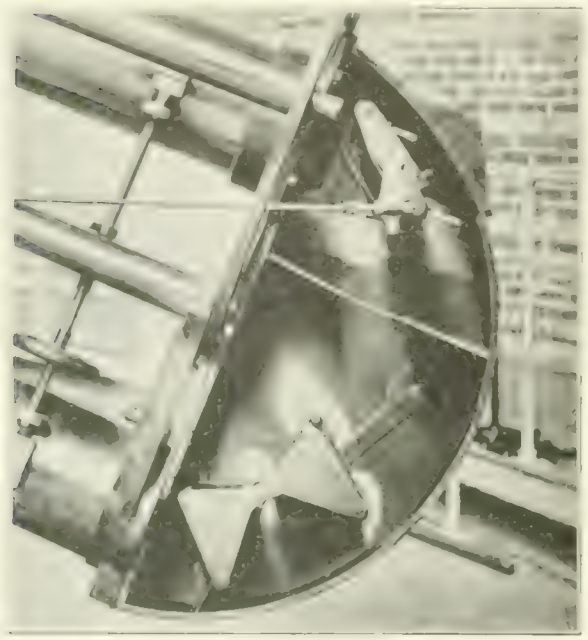
Both the first and the second slits are provided with means of rotation in their own plane. These permit the first slit to be made parallel to the refracting edge of the prisms, and the second slit to be made parallel to the spectral lines. The latter adjustment must be made with great accuracy, on account of the considerable length (8 inches = 20.3 cm) of the slit and the spectral lines. The difficulty is increased by the fact that the box containing the plate-carriage and the second slit must be removed from the spectroheliograph whenever this instrument is detached from the telescope. When replaced on the spectroheliograph, the box is rotated until a projecting arm comes in contact with a strong adjustable stop. In practice little difficulty is experienced in securing and retaining the necessary parallelism of the slit and the lines.

In a spectroheliograph of this size the curvature of the slits necessarily plays an important part. It is obvious that if the first slit were straight and the second slit were given the necessary curvature (twice that of the lines in Fig. 1, Plate II) the image of the Sun would be greatly distorted, flattened on one side and drawn out on the other. In the present instrument a method of overcoming this difficulty, suggested several years ago by Professor Wadsworth,[4] was adopted. The curvature was equally divided between the first and second slits, and the direction of the motion of the photographic plate was made the same as that of the Sun's image. A little consideration will show, when the optical train of the instrument is taken into consideration, that this plan will eliminate the distortion of the image which would be expected to result from the use of curved slits. It is only necessary that the collimator and camera lenses be of the same focal length, and that the speed of the solar image and plate be equal, in order that circular and undistorted photographic images may be obtained. When the curved first slit is used the curvature of the lines corresponds with that shown in Fig. 1, Plate II, which is a full-size reproduction of a photograph of the solar spectrum taken with the second slit removed.

Optical parts.—The collimator and camera lenses are of the portrait-lens type, by Voigtländer. They are of equal aperture and focal length and may be focussed singly or together by means of a rod connecting the pinions which move each lens in its tube. The collimator and camera tubes are provided with a large number of diaphragms, which effectually prevent reflection of light from the inside of the tubes, a point of great importance in the design of spectroheliographs.

[4] W. H. WRIGHT, *Astrophysical Journal*, Vol. V (1897), p. 325.

After passing through the collimator lens the rays meet a plane mirror. From this they are reflected to the first of two prisms which, in conjunction with the mirror, give a total deviation of 180° when the prisms are at minimum deviation for the line in use (Fig. 1). As ordinarily employed, the mirror and prisms are clamped in position for the K line. But if it is desired to pass to another part of the spectrum, the prisms are first set at minimum deviation for the desired wave-length, the setting being made with the aid of a pointer moving over a scale on the lower face of the prism box. The mirror is then moved along the axis of the collimator until a position is reached in which light of the desired wave-length, when reflected from the center of the mirror, will pass centrally through the prisms at minimum deviation. The position of the mirror is read off on a scale on the top of the prism box (Fig. 1 is from a photograph taken with the top of the box removed). The mirror is rotated by means of a tangent screw, controlled by the observer at the second slit by a rod passing up through the frame of the spectroheliograph (Plate I). The tangent screw and the top of the prism box can be removed in a moment, thus giving easy access to the interior. Diaphragms within the prism box prevent diffuse and reflected light from reaching the camera lens.



The relative position of mirror and prisms is of importance, and in this respect the present spectroheliograph is a distinct improvement upon the instrument used in my experiments on Mount Etna. In the case of that instrument the mirror (there in the form of a reflecting prism) stood in front of the camera lens, whereas in the present instrument the mirror is placed in front of the collimator lens. With this latter arrangement the diffuse light from the mirror is dispersed and thus greatly reduced in intensity by its passage through the two prisms.

In this connection it may be remarked that one of the most important elements of spectroheliograph design is the question of diffuse and reflected light. Too much care cannot be taken to eliminate it, both by devices such as have been suggested in the case of the mirror, and by a thorough use of diaphragms and other similar means of protection. A thorough study of this question has been made with several spectroheliographs employed with the forty-inch refractor. During the test of the Rumford spectroheliograph two other spectroheliographs of different design were available for comparison with it. The moving slits, which had been removed from the Kenwood spectroheliograph, were replaced, permitting it to be employed for photographing small areas of the large solar image. A spectroheliograph of the Littrow form suggested by Newall[2] was also constructed. But, in spite of every precaution to eliminate diffuse and reflected light, including modifications of Mr. Newall's design so as to place the first and second slits at a considerable distance from the principal axis of the [illegible] the insertion of a very complete system of diaphragms; and the use of a screen covering the central part of the joint collimator and camera lens (for the purpose of preventing light due to [illegible] much scattered light remained and the photographs did not show satisfactory contrast. The Kenwood spectroheliograph was also deficient in this respect, as the illuminated face of the grating (or that of the 30° reflecting prism sometimes employed [illegible]

In the Rumford spectroheliograph, as has been remarked, these difficulties do not exist, and the resulting photographs clearly show the advantages of this instrument, either for work with two prisms and a mirror, or for that demanding the higher dispersion obtained when a grating is substituted for the mirror.

The question of the best dispersion for a spectroheliograph is one which has been considerably discussed, notably by Michelson.[6] As shown in his paper, the contrast should increase with the resolving power up to a certain point, defined by several conditions, the principal of which is the width of the spectral line employed. In the case of the calcium flocculi, a comparatively small resolving power is sufficient to give the best results. On the whole, it is probable that no important advantage will be gained in this case by increasing the resolving power above that of two 60° prisms (assuming the effective linear aperture of the spectroheliograph in the plane of dispersion to be as great as 5 cm). As compared with gratings, prisms possess certain advantages, though they are not free from disadvantages. In general they have the decided advantage of giving a brighter spectrum, in which the H and K lines are visible, and the diffuse light is also less than with most gratings. On the other hand, the curvature of the spectral lines is much more marked than with gratings, and this circumstance seriously affects the design of the spectroheliograph. On the whole, prisms are usually to be preferred to gratings.

The need of high dispersion is most manifest when the dark lines of the solar spectrum (with the exception of the broad H and K bands) are to be employed in photographing the Sun's disk. As these lines are dark only by contrast, it is of course possible to obtain monochromatic images corresponding to them with the spectroheliograph. But in order that these images may represent the gas or vapor which gives rise to the line, it is absolutely essential that the dispersion be great enough to make the line wider than the second slit, in order that no light from the continuous spectrum on either side of the dark line may fall upon the plate. Misleading results will be obtained unless this condition is fulfilled. In this case, therefore, the dispersion of one or two prisms will not suffice, unless a camera much longer than that of the Rumford spectroheliograph be used. The necessary increase of dispersion is obtained in a very simple manner in the Rumford spectroheliograph. A large plane grating, having the usual adjustments, is mounted on a support which can be substituted in a moment for the support of the mirror in the prism box. The grating employed has 20,000 lines to the inch (7874 to the cm) on a ruled surface $2\frac{5}{8} \times 3\frac{3}{4}$ inches (66×95 mm). Any line in the first-order spectrum can be made to fall on the center of the first prism, whence it is transmitted at minimum deviation through the two prisms of the train. This adds the dispersion of the grating to that of the prisms, and has the additional advantage of reducing the diffuse light of the grating to a minimum. With the grating at present employed the lines of the ruled surface are not long enough to permit the entire length of the first slit to be used: a zone of the solar disk only about 2.5 inches (6.4 cm) wide can be photographed in this way. The dispersion is sufficient to enable photographs to be taken through such lines as those of hydrogen, λ 4226.9 (*Ca*), λ 4383.7 (*Fe*), and a few other of the more intense lines. In order to use narrower lines, still higher dispersion, which is now being provided for in another spectroheliograph, will be required.

In the case of the prominences, the high dispersion of a grating or of several prisms is frequently advantageous (except in eruptions, where the lines are distorted through motion in the line of sight), since the H and K lines are narrower in the prominences than in the flocculi, and are therefore less widened by dispersion; hence high dispersion increases the contrast by decreasing the relative brightness of the sky spectrum. This advantage is nevertheless partly offset by the disadvantage arising from the longer exposure required when high dispersion is used.

Motion of solar image and plate.—In their original design of the mounting for the forty-inch refractor Messrs. Warner & Swasey provided electric motors for the slow motions in right ascension

[6] *Astrophysical Journal*, Vol. I (1895), p. 1.

and guiders. These have proved exceedingly useful, especially in work with the stellar spectrograph, where they are employed to keep the star accurately centered on the slit throughout the exposure. In order to adapt the declination motor for the purposes of the spectroheliograph, it was provided with two sets of change gears, designed by Mr. Ritchey and constructed in the instrument shop of the Observatory. The motion of the focal image of the Sun produced by the motor when these gears are employed is about one minute of arc in four seconds and twenty-four seconds of time respectively. The motion of the telescope when driven by the motor was thoroughly tested, before the spectroheliograph was designed, by photographing the trails of bright stars. It was found to be steady and uniform, the slight jarring of the tube caused by the motor producing no apparent effect upon the photographs.

The motion of the photographic plate behind the second slit, which must correspond exactly with the motion of the solar image over the first slit, is produced by a shaft extending down the telescope tube from the declination motor, to which it is connected by suitable gearing. This shaft runs in ball bearings, and with the two speeds of the motor makes one revolution in seven-tenths of a second and in four seconds respectively. Various means of driving the photographic plate through the motion of this shaft have been employed. These include a double Hooke's joint;[1] a worm gear mounted on a bracket on the spectroheliograph ring at the lower end of the shaft, which drove a drum on which was wound a steel tape connected directly with the plate-carriage; and a grooved pulley connected by a round leather belt with a pulley at the end of the light-tight box in which the plate-carriage moves. This last arrangement is the one now employed. The motion of the carriage is produced by means of two screws, each of one millimeter pitch, which run longitudinally through the box containing the carriage, and are connected with the carriage by means of split-nuts which can be opened and closed by keys on the outside of the box. The pulley on which the leather belt runs is attached to a spur gear, which engages with two other spur gears of equal diameter on the projecting ends of the screw shafts. As the two grooved pulleys are nearly equal in size, the number of revolutions of the screws corresponds closely with the number of revolutions of the shaft on the telescope tube. The exact adjustment of the speed of the plate to that of the solar image is secured by giving these pulleys the proper relative diameters. The circularity of the solar image on the photograph gives an accurate means of testing this adjustment.

From the outset serious difficulty has been experienced in producing an absolutely uniform motion of the plate, which would result in a photograph free from lines or regions of varying density parallel to the slit. These difficulties greatly retarded the completion of the instrument, and though almost wholly eliminated at the present time, lines about one millimeter (or less) apart sometimes appear on the photographs taken with the telescope in certain positions. The end-thrust bearings of the screws have been found to be the most sensitive factor in the production of these lines. Many changes have been made in the screw and its bearings, the nuts and their supports, the plate-carriage and the wheels on which it rolls, etc. The recent substitution of two screws for the single screw formerly employed to drive the carriage has almost wholly eliminated the lines. When the seeing is good and the plates show fine detail, they are usually barely visible or altogether absent, but poor definition renders them more conspicuous. Care must be taken to discriminate between appearances sometimes produced by these lines and those which are of truly solar origin.

The carriage is mounted on ball bearings which run on V-shaped tracks. The plate-holder is placed in the carriage through a door at one end of the light-tight camera box. When thus inserted it is held against the back of the carriage by springs. After closing the door, which forms a light-tight contact with the cloth-covered end of the plate-holder when the carriage is at the end of its run, a small shutter is opened. Through this the slide in front of the plate can be withdrawn without admitting light to the box. After the sliding door is closed, the carriage is

moved a short distance forward on the tracks, and the plate-holder is pushed down in the carriage by two screws, turned by screw drivers which project through the back of the camera box. This brings the film of the photographic plate almost in contact with the jaws of the second slit, which we may suppose to be set on the K line. The split-nuts are then clamped to the driving screws and the motor started. The Sun's image then moves across the first slit, while the photographic plate moves at the same rate across the second slit. At the end of the exposure the split-nuts are unclamped and the plate-carriage moved back to the point where the screws which hold the plate forward in the carriage may be released. After releasing the screws the plate-carriage is moved to the end of its run, the sliding door opened, and the slide inserted in the plate-holder. The hinged door may then be opened, and the plate-holder removed from the carriage.

Method of setting the second slit on a line.—An important element in the design of any spectroheliograph is the means provided for setting the second slit upon any desired line in the spectrum. In the numerous forms of spectroheliographs which I have designed, various methods of accomplishing this have been employed. Two methods, the choice of which depends upon the character of the line selected, are used in the Rumford spectroheliograph. A compound microscope, of variable magnifying power, is mounted opposite the second slit on the camera box. This microscope is supported on a strip of metal running in guides, which permit it to be displaced in a direction at right angles to the second slit. The microscope is focused on the lines of the spectrum when seen through the widely-opened slit. Under these conditions the jaws of the second slit will be sufficiently well in focus, as the focal plane, corresponding with the position of the film when the plate is pushed forward, almost coincides with the plane of the slit jaws. The mirror or grating is rotated by means of the tangent screw until the desired line enters the field of view. A single thread, in the filar micrometer of the microscope, is brought into accurate coincidence with the spectral line by means of the micrometer screw. The second slit is then closed to the desired width, and moved as a whole until it coincides with the micrometer thread. Under these circumstances it must coincide with the line on which this thread has previously been set.

When using the K line it is usually more satisfactory, on account of the faintness of the spectrum and the loss of light in the microscope, to bring the line into position on the slit with the aid of a simple hand magnifier. H is more easily seen than K, and since it gives equally good results with the Rumford spectroheliograph, it is now regularly employed.[8]

As the H and K lines are nearly at the extreme limit of vision, it is sometimes advantageous to make the first slit tangential to the solar image, where the bright reversal of the line may be seen. This may be set upon more accurately than the broad dark shade. The use of a fluorescent eyepiece might facilitate setting on the H and K lines. The expedient of setting on a line by the aid of the overlapping spectrum may sometimes prove useful when a grating is used without prisms. In the Rumford spectroheliograph this method is not available, since a grating is used only in conjunction with prisms, which effectually eliminate the overlapping spectra.

When it is desired to photograph the calcium vapor at different levels in the flocculi, the method described on p. 16 must be employed. This requires that the second slit be set at various points on the broad H or K bands, at known distances from the center. If we assume that the first photograph of a series corresponding to different levels is made with the second slit set at the center of the H band, successive photographs may be obtained, without removing the plate-holder from the carriage, by moving the second slit as a whole through any desired number of divisions of the micrometer head of the screw connected with it. This method is much more rapid than repeated settings with the microscope would be, thus permitting various stages of a rapidly changing disturbance to be photographed.

[8] Since K is brighter than H, it would usually be preferred with telescopes which absorb less light of this wave-length. The flocculi seem to have the same form in images obtained with either of these lines.

For work in the ultra-violet, where the lines cannot be directly observed, the expedient may be employed of photographing the spectrum and measuring the distance on the plate from a known line in the visible spectrum to the desired line in the ultra-violet. An auxiliary microscope, provided with a right-angle prism, and projecting through the side of the camera tube so as to receive light from the spectrum on one side of the second slit, may then be placed at a position corresponding to this measured distance, and the setting effected by bringing the visible line into coincidence with a thread in the eyepiece of this microscope. If the distance is not too great, the same thing can be accomplished by observing the visible line through a small door in the brass plate which carries the second slit.

Photographs may be made simultaneously in two or more lines, if certain conditions be fulfilled. The most important requirement is that the solar image shall be in focus on the first slit for each of the wave-lengths in question. Except in the case of two lines symmetrically placed on opposite sides of the point of inflection of the color curve of the telescope objective, this condition cannot be fulfilled with an instrument like the forty-inch Yerkes refractor, where the color curve is very steep in the blue and violet. For this reason no experiments in this direction have as yet been attempted with the Rumford spectroheliograph. With the new Snow horizontal telescope the exclusive use of mirrors should eliminate the difficulty arising from chromatic aberration, and render such work feasible.

Adjustments.—The adjustments of the Rumford spectroheliograph are made as follows:

1. Square up the prisms on their leveling screws by observing reflections from the three faces.

2. Square up the mirror by observing the image of a fine wire fastened across the center of the first slit.

3. Focus the collimator by observing the image of a wire returned to the plane of the slit by the mirror standing normal to the axis.

4. Determine the position of minimum deviation of the prisms for the H line.

5. Focus the camera by photographing the solar or sky spectrum in the H region.

6. Determine the magnification parallel to the slit by placing wires across the first slit, photographing the spectrum, and comparing the distances between lines on the photographs with the distances between the wires themselves.

7. Check the adjustment of the mirror by placing a wire across the center of the first slit and noting whether the image falls on the center of the second slit.

8. Make the first slit perpendicular to the direction of dispersion by placing a wire across the center, photographing the spectrum with the slit at various position angles, and measuring the plates to find whether the central line is perpendicular to a tangent at the center of the curved spectral lines.

9. Confirm the prism for minimum deviation of H, using an electric arc containing calcium, and [illegible] by Newall's method.

10. Make the second slit parallel to the spectral lines by observing them at the ends and center.

11. To determine whether the motion of the plate is parallel to the direction of dispersion: Make a series of photographs of the spectrum with wide second slit, moving the carriage between exposures. Determine by measurement whether the dust lines are perpendicular to a tangent at the center of the spectral lines.

12. To set the first slit at right angles to the motion of the forty-inch telescope in declination: Draw on a plate in the visual focus a line perpendicular to the curved slit at its central point. Set the telescope on the Sun, and with the spectroheliograph in position, run until the Sun's limb exactly follows this line when the [illegible] is illuminated by the solar.

13. Adjust the speed of the plate carriage until the diameters of the solar image, as measured in different [illegible] agree.

Before making the above adjustments it is assumed that the first and second slits have been given the proper curvature for eliminating distortion of the image. This is done by photographing the H line through the widely opened second slit, using a straight first slit. The curvature of the H line is then determined by measurement of the photograph, and the first and second slits are made of twice this radius of curvature.

PRELIMINARY ACCOUNT OF RESULTS OBTAINED WITH THE RUMFORD SPECTROHELIOGRAPH

Although the present paper is intended mainly as a description of the Rumford spectroheliograph, it seems desirable that it should be accompanied by some recent photographs of solar phenomena, since in this way the uses of the spectroheliograph for various classes of work can be most easily made clear. The publication of the photographs, however, necessarily involves some preliminary remarks on the working hypothesis which has been employed to interpret them. The hypothesis is used mainly as a guide to further research; for, while it seems to describe in a fairly satisfactory manner many of the phenomena photographed, it is of course open to modification or rejection in the light of future results.

Prior to 1903 the spectroheliograph was used for experimental purposes, the numerous photographs obtained during the Sun-spot minimum being of service mainly in perfecting the adjustments of the instrument. It had been expected that the spectroheliograph would be transferred from the forty-inch refractor to the thirty-inch cœlostat reflector for the purposes of the daily record; but the destruction of the latter instrument by fire in December, 1902, prevented the realization of this plan.[9] The work with the forty-inch refractor was accordingly resumed in February, 1903, and since the latter part of that month photographs of the calcium flocculi have been made on each clear day (Sundays usually excepted). Since early in April this series has been supplemented by a daily series of (low-level) photographs, made with the slit set at some distance from the center of the H or K band, and since May 16 photographs have been made as often as possible with the $H\beta$ line. In addition to this routine work, many photographs of special regions have been taken in a study of the calcium vapor at various levels, and some results have also been obtained with the calcium line λ 4226.9, the iron line λ 4383.7, and with various other dark lines. It will thus be seen that while the material represented by the photographs obtained with the Rumford spectroheliograph is not yet sufficient for extended generalizations, the variety of phenomena recorded is such as to call for some comment here. A more complete discussion of the results must be reserved for a future occasion.

ON THE NATURE OF THE CALCIUM FLOCCULI

In my first published note on the bright calcium regions recorded for the first time with the Kenwood spectroheliograph, I briefly described the results in the following words:

> The reversed regions are of great extent, and in appearance closely resemble faculæ. Several explanations may be suggested to account for them. They may be:
>
> 1. Ordinary prominences projected on the disk.
> 2. Prominences in which H and K are bright, while the hydrogen lines are absent.
> 3. Faculæ.
> 4. Phenomena of a new class, similar to faculæ, but showing H and K bright, and not obtained in eye observations or ordinary photographs because of the brilliant background upon which they are projected.[10]

It was subsequently shown that the bright calcium regions in general coincide closely with the faculæ, and it was concluded that they represent the hot calcium vapor in the upper part of the faculæ and in the lower part of the adjoining chromosphere. Fig. 2, Plate II, which is reproduced from a photograph of the K line taken at the Kenwood Observatory, shows that the bright reversals of the K line frequently occur in regions of the disk where the continuous spectrum is considerably strengthened. These regions are the faculæ proper. The faculæ, though apparently but little brighter than the photosphere, are conspicuously visible near the Sun's limb. This is probably due to the fact that they reach a higher level, and thus escape much of the general absorption exercised by a comparatively thin stratum of a smoke-like nature, which lies in close contact with the photosphere. The faculæ are, in general, the regions above which the calcium vapor is hottest and most brilliant. But it appeared later that the calcium vapor is not confined to the faculæ, but extends beyond their boundaries and

[9] Through the generosity of Miss Helen Snow, the cœlostat reflector has been rebuilt, and is now in regular use. A spectroheliograph will soon be employed with it.

[10] *Astronomy and Astrophysics*, Vol. II (1892), p. 159.

frequently occurs in regions of the solar disk where they are absent. The generally close coincidence of the calcium clouds with the faculæ, and a natural hesitation to propose a new name before the results obtained with the spectroheliograph had been sufficiently studied, led me to apply this term to the bright calcium regions photographed with the spectroheliograph. From my present point of view I think it would have tended to clearness, as M. Deslandres has pointed out, if some other name had been adopted.

M. Deslandres' latest explanation of the calcium regions is undoubtedly more nearly correct than my earlier one, though at the time I did not appreciate this. His solar investigations at the Paris Observatory were continued for some years to the photography of the spectrum of various parts of the Sun's disk, but in 1894 he undertook work with the spectroheliograph. The bright reversals of the H and K lines photographed by M. Deslandres on the Sun's disk were at first considered by him to represent the prominences; later he ascribed them to bright regions at the base of the prominences, and finally he spoke of them as the brighter regions at the base of the chromosphere projected on the disk. This last designation now appears to me to describe the facts much more accurately than the term "faculæ" (meaning calcium vapor of the faculæ) at first employed by myself. In suggesting the term *flocculi* (*floccŭlus*, dim. of *floccus*, "a bit of wool"), to distinguish the vaporous clouds photographed on the disk from the underlying faculæ, I have distinctly avoided the use of a name which might in any sense be taken as indicating the nature of the phenomena. A glance at Plate III will show that the word is more or less descriptive of the photographs, so far as their appearance is concerned.[11] It is necessary to speak of calcium flocculi, hydrogen flocculi, etc., as the photographs show that the forms of the various vapors in the same part of the disk are not identical. Some of the phenomena comprised under this name are undoubtedly prominences seen in projection, but most of them correspond to much lower levels, near the base of the chromosphere, or within the reversing layer.

MINUTE STRUCTURE OF THE FLOCCULI

The extensive literature which embodies the long discussion regarding the "willow leaf" and "rice grain" structure of the photosphere has in large part become obsolete since the publication of Langley's important paper "On the Minute Structure of the Solar Photosphere," and of Janssen's excellent photographs, now generally accessible in the first volume of the Annals of the Observatory of Meudon. After speaking of the cloud-like character of the photosphere, Langley goes on to describe the more minute details in the following words:[12]

Under high powers used in favorable moments, the surface of any one of the fleecy patches is resolved into a congeries of small intensely bright bodies, irregularly distributed, which seem to be suspended in a comparatively dark medium, and whose definiteness of size and outline, although not absolute, is yet striking by contrast with the vagueness of the cloud forms seen before, and which we now perceive to be due to their aggregation. The "dots" seen before are considerable openings caused by the *absence* of the white nodules at certain points, and the consequent exposure of the gray medium which forms the general background. These openings have been called pores; their variety of size makes any measurements nearly valueless, though we may estimate in a very rough way the diameter of the more conspicuous at from 2″ to 4″. The bright nodules are themselves not uniformly bright (some being notably more brilliant than their fellows and even unequally bright in portions of the same nodule), neither are they uniform in shape. They have just been spoken of as relatively definite in outline, and this outline is commonly found to be irregular on minute study, while it yet affects, as a whole, an elongated or oval contour. Mr. Stone has called them rice-grains, a term only descriptive of their appearance with an aperture of three to four inches, but much used by me personally. It depicts their whiteness, their relative individuality, and their approximately long axis, but not their irregular outline nor a certain tendency to foliate structure which is characteristic of them, and which has not been sufficiently remarked upon. This irregularity and diversity of outline have been already observed by Mr. Huggins. Estimates of the main size of these bodies vary very widely. Probably Mr. Huggins has taken a judicious mean in averaging their longer diameter at 1″.5, and their shorter at 1″, while remarking that they are commonly between 2″ and 3″, and sometimes less than 1″ in length.

[11] This name has however been found by E. E. Barnard unsuitable for photographs
[12] Smithsonian Contributions to Knowledge, Vol. XII (Washington, 1881)

. . . . In moments of rarest definition I have resolved these "rice-grains" into minuter components, sensibly round, which are seen singly as points of light, and whose aggregation produces the "rice-grain" structure. These minutest bodies, which I will call granules, it will appear subsequently can hardly equal 0".3 in diameter, and are probably less.

. . . . It seems to me that there is no room for doubt that "filaments" and "granules" are names for different aspects of the same thing; that filaments in reality are floating vertically all over the Sun, their upper extremities appearing at the surface as granules; and that in the spots we only see the general structure of the photosphere, as if in section, owing to the filaments being here inclined.

. . . . Speaking without reference to spectroscopic investigations, it seems to me that we have in the behavior of our filaments a presumption as to the existence of ascending currents in the outer penumbra, and of both ascending and descending currents at the umbral edge; ascending ones being the more usual.

An examination of the minute calcium flocculi photographed with the Rumford spectroheliograph will show that they closely resemble the photospheric "grains" described by Langley and illustrated in Janssen's photographs. Fig. 3, Plate IV, is reproduced from one of our negatives on the scale chosen for the majority of the photographs in Vol. I of the Meudon Annals. This photograph was made with the slit set at the center of the H line on a day when the seeing was particularly good. In Fig. 5, Plate II, squares 10 seconds of arc on a side are shown. These permit of an accurate determination of the size of the individual elements of the structure. Measurements made on our best negatives show that the minute calcium flocculi range in diameter from less than one second to several seconds of arc, thus corresponding closely with the "grains" of the photosphere.

On the working hypothesis at present employed to interpret the results obtained with the Rumford spectroheliograph, it is considered that these minute flocculi are columns of calcium vapor, rising above the columns of condensed vapors of which the photospheric "grains" are the summits.

On such an assumption it becomes interesting to inquire whether the larger calcium flocculi are made up of similar columns of calcium vapor. As a rule, the seeing is hardly good enough to permit a decision to be reached on this point. But under the best conditions there appears to be distinct evidence of a filamentary structure, the filaments seeming to spread out like the branches of a tree (Fig. 2, Plate IV). It is evident that much light could be thrown on the question if it were possible to photograph sections of the flocculi at different elevations above the photosphere, since in this way the form and size of distinct columns of calcium vapor, if such were present, could be determined at different levels.

FORM AND EXTENT OF CALCIUM FLOCCULI AT VARIOUS ELEVATIONS ABOVE THE PHOTOSPHERE

Fortunately, it is possible to accomplish this very result, if the present mode of explaining the photographs may be regarded as sound. We have already had occasion to consider some of the characteristics of the H and K reversals in the chromosphere. In the solar spectrum itself the appearance of the H and K lines clearly indicates that calcium vapor occurs under widely different conditions of intensity at various levels above the photosphere. It is a well-known fact that if a considerable quantity of calcium vapor is introduced into an electric arc, broad bands, bright in the center and fading toward both edges, will appear at the position of the H and K lines (Fig. 4, Plate II).[13] The width of the bands may be taken as an approximate measure of the density of the calcium vapor, which decreases toward the outer part of the arc, where the bands are reduced to narrow lines. The narrow dark lines at the center of the bright bands are caused by the absorption of the comparatively cool and rare calcium vapor in the outer part of the arc.

A similar condition of things undoubtedly exists in the Sun. In the first place, we have broad diffuse dark bands in the solar spectrum at H and K, produced by comparatively dense calcium vapor close to the photosphere. For convenience of reference these bands will be called H_1 and K_1. As the bright reversals at the base of the chromosphere, when photographed at the Sun's limb with a

[13] Photographed in the electric arc with the solar spectrograph of the Snow horizontal telescope. The grating temporarily employed gives strong ghosts, which are conspicuous in the photograph.

tangential slit, or at a total eclipse, are much narrower than these bands, it may be concluded that the dense calcium vapor in the chromosphere lies beneath the lowest level that can be observed at the limb. On the basis of Kirchhoff's law, the comparative darkness of these bands in the solar spectrum would be ascribed to the fact that the calcium vapor which they represent is cooler than the photosphere below it. With increasing elevation, in a region of lower pressure, the density of the vapor decreases, and to this decrease of density there corresponds a decrease in the width of the bands. In the lowest portion of the chromosphere that can be observed at the Sun's limb, the density of the vapor is so far reduced that the broad and diffuse bands are replaced by fairly well-defined lines (H_2, K_2), which maintain their width up to a certain elevation in the chromosphere and then grow narrower, thinning out to much narrower lines (H_3, K_3) in the upper chromosphere and prominences (Fig. 3, Plate II). On the disk H_3 and K_3 appear as fairly narrow dark lines at the center of the broad H_1 and K_1 bands. They occur in practically all parts of the disk, but differ greatly in intensity in different regions. Every bright calcium flocculus on the disk is characterized by the presence of bright H_2 and K_2 lines at the center of H_1 and K_1, with narrow dark H_3 and K_3 lines, due to the absorption of the cooler and rarer vapor in the upper chromosphere, superposed upon them. Intensity curves showing these peculiarities of the H and K lines are given by Jewell in the *Astrophysical Journal*, Vol. III (1896), p. 100, where the displacements of the lines are also discussed. They are also illustrated in the photographs reproduced in Plate II.

From a strict application of Kirchhoff's law it would appear that the calcium vapor in the lower chromosphere is actually hotter than the calcium vapor which lies above and below it. It seems improbable that the law can be rigorously applied in this case, and hence it may be necessary to attribute the strong radiation of the intermediate layer to causes other than temperature alone.

In view of the composite character of the calcium lines, it should be possible with the spectroheliograph to photograph sections of the calcium flocculi at levels corresponding to their several elements.[4] If, for example, the second slit were set at the extreme edge of K_1, the resulting photograph should show only that calcium vapor which is dense enough to produce a line of this breadth; *i. e.*, a section across the base of the calcium flocculus should be obtained. Under no circumstances could the upper and rarer portions of the flocculus be shown on such a photograph, since the line they produce is not broad enough to enter the second slit. If the slit were set nearer to the center of the line, the photograph should represent a section of the flocculus corresponding to a higher level, where a narrower line is produced. It is evident that while none of the higher and rarer calcium vapor could be shown in this photograph, it might nevertheless include regions lying below it, where the calcium vapor is dense enough to produce a broader line. However, since the calcium vapor is rising from a region of high pressure to one of a much lower pressure, it must expand as it rises, and therefore a section at any level should in general be of a larger area than a section of the same flocculus at any lower level. As a consequence of the increasing extent of the vapor with the altitude, and the increase of brightness observed when passing from K_1 to K_2, a photograph corresponding to a given level is not necessarily affected in any considerable degree by the existence of the denser vapor below, except in cases where the high-level vapor does not lie immediately above the low-level vapor. Low-level phenomena, even when very bright, may be wholly concealed by general excess of radiation, or in some cases by absorption, of the calcium-vapor at high levels. Moreover, it is of course to be understood that the term "level" is not used here in a strict sense. A section of a large flocculus photographed with K_2 might for example correspond to a much greater height above the photosphere than that of the minute flocculi shown on the same photograph. It must never be forgotten, when examining the photographs, that composite effects are very likely to be present.

Such considerations regarding the possibility of photographing sections of the flocculi at different levels are borne out by the photographs, as will be seen by reference to the accompanying illustrations. Plate V represents the spot group of 1903, April 29, as photographed with four different settings of the second slit. These were taken within such time limits and in such an order that, as no distinctly eruptive phenomena were present, the principal differences between the photographs are therefore to be attributed to differences in the extent and brightness of the vapor at various levels, and not to changes going on in the Sun at the time.

Fig. 1 shows the various spots of the group, with faint indications of the surrounding faculæ. This photograph was obtained with the slit set on the continuous spectrum at λ 3924, and the form of the faculæ proper, as defined by variations in the brightness of the continuous spectrum, is given in this case. Fig. 2 was made with the slit set at λ 3929, just within the edge of the broad K_1 band. By comparing this with Fig. 1 it will be seen that even the lowest calcium vapor sometimes overhangs and partly covers the penumbra of spots, while the outline of this vapor differs materially from that of the faculæ shown in Fig. 1. Fig. 3 is from a photograph made with the slit set at λ 3932, on the broad dark band near the center of K_1. It will be seen that at this level the vapor has expanded very considerably, so that details of some spots clearly visible in Fig. 2 are completely hidden. Fig. 4 is from a photograph obtained when the slit was in such a position and of such width as just to inclose K_2. This photograph should therefore represent a section of the calcium vapor at the level corresponding to the second stratum referred to above. Here the calcium vapor is brighter and much more extensive than in the stratum below, so that a photograph of the entire Sun taken in this way offers a marked contrast to a photograph taken with the second slit set on K_1 at some distance from the center. It has not hitherto been possible to make photographs corresponding simply to K_3, since very high dispersion will be required in order to prevent the second slit from receiving light from the bright line (K_2) on which K_3 lies. Other series of photographs showing similar differences are reproduced in Plates VI and X to XV.

The assumption that these photographs represent sections of the calcium flocculi at different elevations seems to be the simplest and most satisfactory way of explaining the results obtained. Partial reflection of the bright K_2 line at the edges of the second slit would not suffice to account for the results, since in this case the images of the flocculi would be precisely similar in form in all cases, and would merely vary in intensity. Again, it might be held that the faculæ rise above the dense calcium vapor represented by the broad dark bands at H_1 and K_1, and that they would be shown with increasing contrast toward the center of the bands, on account of the protection from the brilliant light of the photosphere which these afford to the plate. Here again, however, the forms corresponding to all positions of the second slit on H_1 and K_1 should be the same, and they should correspond with those of the faculæ. No satisfactory means of explaining the results except on the assumption that they represent different levels has hitherto presented itself. Essentially conclusive evidence in favor of this assumption is afforded by the photographs of the recent great Sun-spot (Plates X to XV).

With the aid of this additional means of research we may return to a consideration of the structure of the flocculi. It has already been remarked (p. 15) that the general surface of the Sun appears to be covered with columns of bright calcium vapor, varying in diameter from less than a second to several seconds of arc, separated by darker spaces, which correspond in appearance to the darker spaces that separate the photospheric "grains." The summits of these columns seem to lie in the second stratum, corresponding to the bright lines H_2 and K_2. The appearance of the disk, when photographed with the slit set on H_2 at λ 3968.6, is shown in Fig. 3, Plate IV. We must endeavor to explain why the appearance of this photograph differs so markedly from that of Fig. 1, Plate IV, where we see no very clear indication of the existence at the H_1 level of the columns of calcium vapor whose summits appear as minute flocculi in the photographs of the second stratum.

In a spectrograph with the slit set at the center of H or K the contrast between adjacent regions of the Sun's surface depends upon several factors, two of which are in some cases closely related, while in others they are apparently independent of each other. These are the intensity of the dark K_3 line, which may be photographed over almost the entire surface of the Sun, and the intensity of the bright K_2 line, which varies greatly in different regions. Suppose the bright K_2 line to be absent. In this case the contrast between different regions would depend, to a considerable degree,[1] upon variations in the absorption of the calcium vapor in the upper and cooler parts of the chromosphere. If the second slit were not much wider than K_3 a particularly cool region, in the chromosphere or in a prominence, might show as a dark structure.

Let us now suppose, as is actually the case in practice, that K_2 appears as a bright line at numerous points on the Sun's disk. In general, being produced under greater pressure in the lower part of the chromosphere, the bright K_2 should be broader than the dark K_3, while the latter line must appear superposed upon K_2 in all cases but one. This exception is the region over the umbra of Sun-spots, where the denser calcium vapor corresponding to K_2 is absent, and the rarer vapor at a higher level gives a *bright* K_3 line (usually not very intense) on the darker background of the spectrum of the umbra.

It is easy to see that such variations in the relative intensities of bright K_2 and dark K_3 as occur in all parts of the disk must result in photographs showing much greater contrast than is obtained in those corresponding to the K_1 level. For in the latter case the second slit, being set at some distance from the center of K, receives no light from K_2 or K_3, and shows only such variations of intensity as are due directly to differences in the radiation of the dense low-level calcium vapor. The evidence afforded by photographs taken at successive levels goes to show that in passing from the lower K_1 region up into the K_2 region, the calcium vapor increases greatly in radiating power. For example, eruptive phenomena which are quite inconspicuous when photographed at the lower K_1 levels, become more and more brilliant as the second slit is moved for successive photographs nearer and nearer to the center of K. What is true of eruptions is also true in large degree of the smaller columns of calcium vapor, which rise from closely set points all over the Sun's surface, and produce the granulated appearance which is so striking in the K_2 photographs.

These considerations would seem to throw some light on the pronounced difference in contrast between K_1 and K_2 photographs of the solar surface. In the brighter flocculi the contrast in the upper K_1 levels is marked, though it almost wholly disappears at the lowest K_1 level. But in the minute flocculi, which probably lie at lower levels than the large flocculi, the brightness at the K_1 level does not appear to be sufficiently great to give strong contrast effects. The marked increase in brightness which is characteristic of K_2, sometimes enhanced by an increase in the strength of the dark K_3 line in adjoining regions, tends greatly to heighten the contrast obtained when the second slit is set between K_2 and K_3.

In the larger flocculi the surmise of a structure composed of expanding columns of calcium vapor seems to be borne out by the photographs. Compare, for example, Figs. 1 and 2 in Plate IV. At the lower level (Fig. 1) the flocculus is resolved into a series of well-defined elements, of comparatively small area. At the higher level (Fig. 2) the area of the entire flocculus is greatly increased, and there seems to be evidence (hardly visible in the cut) that the columns composing it have arched over, so that they are no longer seen end on. Few photographs are sufficiently well defined to bring out such details, and it cannot be said with certainty that the effects seen at the higher level are always due to separation and bending of the columns, as well as to expansion of each of the individual columns. In any event, the increase in area at this level is sometimes very great, in many cases sufficient to cover not only the penumbra, but also entire spots. Another illustration of the expansion at

increasing altitudes may be seen in the four photographs, corresponding to different levels, which are reproduced in Plate VI. A much finer illustration is afforded by the photographs in Plates X to XV of the recent great Sun-spot.

DARK CALCIUM FLOCCULI

As already remarked (p. 18), the occasional great strength of K_3, especially in regions where K_2 is not present, would lead one to expect that *dark* calcium flocculi might sometimes appear on the photographs. The discovery of dark hydrogen flocculi (p. 20) led us to make a careful examination of our photographs with reference to the possible presence of such objects. In previous work nothing of this kind had been noticed, the darker spaces between bright calcium flocculi having been supposed to represent a general background of calcium vapor, less highly radiating than the flocculi themselves, but exhibiting no such structure as would be expected to appear in case distinct regions, of exceptional absorbing power, were present. Few indications of dark calcium flocculi have indeed been found, but in certain cases there can be no doubt that such phenomena actually exist. One of these cases is illustrated in Fig. 3, Plate VIII. The presence in this region of the Sun of a very dark hydrogen flocculus (Fig. 4) led us to examine the corresponding K_2 photograph. An exceptionally dark structure, corresponding in its general form with the dark hydrogen flocculus, was found in the same position. The two dark regions shown in these photographs resemble each other quite as closely as the dark hydrogen flocculi ordinarily resemble the corresponding bright calcium flocculi.

It is an interesting fact that a K_1 photograph taken at the same time showed no evidence of the presence of this dark region. In other similar cases the same thing has been found to be true. For example, on Fig. 4, Plate V, a dark structure is shown extending upward to the right from a small spot lying a short distance to the southwest of the largest one of the group. In Fig. 3, which corresponds to a lower level, this dark structure is not present, nor can it be seen at the still lower levels represented in Figs. 1 and 2. It will be noticed in Fig. 4 that this dark structure seems to be a part of an extensive dark region which almost completely surrounds the group of calcium flocculi. Similar appearances are found on many of our negatives and may be seen, though not to good advantage, in Figs. 2 and 3, Plate VII, and in Fig. 4, Plate VI. It seems possible that we have here some indications of the cooler K_3 calcium vapor, which rises to a considerably greater height than the K_2 vapor of the bright flocculi, and spreads out so as to cover a much larger region of the Sun's surface. Evidences of similar dark regions may be found in the immediate surroundings of the great Sun-spot, illustrated in Plates XI, XIII, XIV, and XV. These plates also afford several examples of better-defined dark structures superposed upon the bright K_2 flocculi.

From these results it appears, as might be expected, that the dark calcium flocculi are comparatively high-level phenomena, either in the upper part of the chromosphere or in the prominences themselves. It is not yet possible to distinguish with certainty the exact level at which they occur in any given case, but this, and other related questions, can perhaps be solved when it becomes possible to photograph the disk with the K_3 line. There may be some difficulty in making such photographs, since the dispersion must be so high as to exclude completely the brilliant light of K_2 from the second slit. If successful, photographs taken in this way will probably show the calcium prominences as dark regions projected upon the disk.

HYDROGEN FLOCCULI

The method of photographing the Sun with the aid of the dark Fraunhofer lines has already been explained (p. 9). The spectroheliograph is employed exactly as in the case of the bright calcium lines, but the dispersion is increased sufficiently to insure that the width of the dark lines shall be greater than that of the second slit. Under such circumstances photographs corresponding to the hydrogen lines, or to any other dark lines of sufficient width, may be obtained.

The first photograph made with a dark hydrogen line ($H\beta$) was taken with the Rumford spectroheliograph on May 16, 1907. On developing the plate we were surprised to find a structure differing materially from that obtained with H_2 and K_2. Closer examination, and a comparison of the photograph with a K_2 photograph made on the same day, showed that the bright calcium flocculi were replaced on the $H\beta$ photograph by *dark* structures of similar, though by no means identical form. There could be no doubt about the adjustment of the $H\beta$ line on the second slit, since a prominence was shown on the photograph extending above the Sun's limb. At a point near a Sun-spot a brilliant object appeared. The same bright object was found on a high-level K_2 photograph, but it did not appear on a K_1 photograph. This was confirmed by other exposures.

The results given by this first photograph have been borne out in subsequent work. It is found that the hydrogen flocculi are in general dark, though they are sometimes bright in disturbed regions, usually in the neighborhood of Sun-spots. Figs. 1 and 2, Plate VIII, show bright calcium flocculi and the corresponding dark hydrogen flocculi. These are not suitable for an exact comparison of form, since the time interval which separates them is too long to insure the absence of change. Figs. 1 to 4, Plate IX, permit a better comparison to be made, and also show some *bright* hydrogen flocculi (Fig. 2, west of spot). In comparing these photographs three points must be borne in mind. In making the photograph reproduced in Fig. 3, the second slit was not set properly on the $H\beta$ line. For this reason, the true hydrogen flocculi are properly shown only in the central part of the figure. Moreover, this photograph was not as accurately in focus as the others. Finally, in reproducing the photographs the contrast was unduly increased during the photo-engraving process in the case of Figs. 1 and 2, which makes the luminous background appear too bright.

With these points in mind the photographs may be compared. It will be seen that while the outlines of the dark hydrogen flocculi correspond in a general way with those of the bright calcium flocculi, there is nevertheless a marked difference in the characteristic features. The hydrogen flocculi seem to have a definiteness of structure in striking contrast with the formless masses of the calcium flocculi.

One of the first questions that suggest themselves in examining these photographs is with regard to the distance above the photosphere of the hydrogen which produces these dark regions. By comparing the same Sun-spot, as shown in corresponding photographs of the calcium and hydrogen flocculi (Plate VIII), it will be seen that the spot usually appears smaller in the latter case, apparently because the penumbra is more completely covered by hydrogen clouds which radiate more light than the penumbra does. The umbra, on the other hand, appears quite dark in these photographs, from which we may conclude that in this case any bright hydrogen line that may extend over it must be very faint. The phenomena shown in the hydrogen flocculus surrounding the recent great Sun-spot, Fig. 2, Plate XI, seem to illustrate a more complex condition of things. Some of the smaller spots of the group are completely blotted out by the overlying clouds of hydrogen. In certain places brilliant hydrogen flocculi are seen, which usually coincide in position with corresponding bright calcium flocculi. These are doubtless eruptive in character and of comparatively short duration; as already remarked, they are faint or invisible in the very low level calcium photographs. In the case of hydrogen we thus have bright eruptive phenomena, and also, in the immediate neighborhood, the dark masses which usually constitute the hydrogen flocculi. We also find possible indications of bright hydrogen flocculi, not eruptive in character, in the vicinity of Sun-spots (see, for example, Fig. 2, Plate VIII). There seems to be some evidence that the temperature conditions may sometimes change sufficiently to transform a dark hydrogen flocculus into a bright one. Doubtless in some regions the temperature is exactly at the critical point, which would render the flocculus invisible. The whole subject is one which will require much study in the future, and in the present paper it is not our intention to do more than merely to suggest some of the principal characteristics of the phenomena. We have reason to believe from the photographs obtained that the second slit did not exactly coincide with the

center of the $H\beta$ line, that it will be possible to photograph the hydrogen flocculi at low and at high levels, as we have done in the case of the calcium flocculi.

Present indications seem to point to the view that the extensive dark regions photographed when the slit is set at the center of $H\beta$ are hydrogen prominences seen in projection on the Sun's disk. There can at least be no doubt that they frequently occur at points on the disk where large prominences are present. On June 12, for example, a large hydrogen prominence was photographed with $H\beta$ at the east limb of the Sun. Cloudy weather prevented further photographs from being taken until June 15, but on that date an extensive dark region was photographed with the $H\beta$ line at the point on the disk where this prominence should have been carried by the Sun's rotation. It of course does not follow that the dark region was not due to the absorption of the hydrogen in the chromosphere below the prominence. But it seems reasonable to suppose that since the hydrogen gas must cool by expansion in rising to higher levels, the strongest absorption would take place in the prominence, rather than in the chromosphere below. On such a view the more extensive dark hydrogen flocculi would be regarded as quiescent prominences seen in projection, while most of the smaller flocculi might still be due to absorbing masses in the upper part of the chromosphere.

CONCLUDING REMARKS

In his recent important paper on the solar eclipse of May 28, 1900, Mr. Evershed, in attempting to explain the predominance of enhanced lines in the spectrum of the flash, gives the following arguments in favor of his idea that "the spark and arc conditions may *co-exist* at the same altitude above the photosphere":

> It is well known that the outer limit of the chromosphere, as seen in the line α of hydrogen, presents a structure of small filaments like blades of grass covering the entire surface, and very unlike the diffused, indefinite limit which a true atmospheric envelope might be expected to present.
>
> According to Secchi, "at the base of the chromosphere the hydrogen has the shape of small, close filaments which seem to correspond with the granulations of the photosphere."
>
> This structure suggests that the chromosphere is in reality a region of innumerable small eruptions of the same nature as the jets of highly luminous gas which are constantly to be seen with the spectroscope in all regions of the Sun's limb. It is probable, indeed, that these jets, and the larger eruptive prominences, are in reality only the more pronounced manifestations of a phenomenon occurring on a smaller scale everwhere over the solar surface.
>
> The highly heated gases composing these eruptions, which may be supposed to originate below the photospheric level, would lose heat as they ascended by adiabatic expansion and by radiation, and at a certain elevation would precipitate the more refractory substances as highly luminous clouds, forming, in fact, the photospheric granules and the columnar filaments observed in Sun-spots. But the gaseous streams, deprived of their condensable materials, would continue to ascend above the photosphere, finally becoming diffused in the region of the chromosphere. The expanded gases, subsequently subsiding in a relatively cooled condition, would form a strongly absorbing atmosphere settling down uniformly and slowly upon the photosphere, and through which the ascending streams would be forced.
>
> If this really represents roughly the actual state of things, it is clear that the temperature conditions represented by the electric spark and by the arc may both exist at the same altitude above the photosphere, the spark condition in the highly heated ascending gases and the arc condition in the cooler descending gases.[16]

It will be observed that Mr. Evershed's words, written some time before most of the photographs described in the present paper had been obtained, accurately describe some of the phenomena recorded on our plates. Unfortunately, we are not yet able to say whether the minute flocculi are to be regarded as eruptive in character, nor can we state whether the enhanced lines (other than those of calcium) are characteristic of them. It is perhaps worthy of remark, however, that the calcium line $\lambda 4226.7$ fails to show a granulated structure at all comparable in appearance with that given by H_2 or K_2. But at present this fact is hardly to be taken as significant, since the technical difficulties of obtaining thoroughly satisfactory photographs through such narrow dark lines are too great to be

[16] *Phil. Trans.*, Vol. CCI (1903), pp. 471, 472.

wholly overcome with our present apparatus. For the same reason we prefer to base no conclusions at present upon the differences in structure indicated by photographs which we have taken with the H and K and the 4227.0 lines of calcium. The only iron line with which we have hitherto obtained photographs which are at all satisfactory (λ 4383.7) is not an enhanced line, and therefore is not suitable for the purposes of the present inquiry. It is hoped that this and other similar questions may be investigated with the new spectroheliograph which is now being constructed for use with the Snow horizontal telescope.

Another question to which we can only refer in the present paper concerns the motion in the line of sight of the calcium vapor above the solar surface, as related to the form of the calcium flocculi at different levels. A long series of measures of H_2 and K_2, and also of H_3 and K_3, which have been made by Mr. Adams on photographs of the spectrum taken here, indicates that in general the vapor corresponding to the dark H_3 and K_3 lines is ascending, in regions which lie above the bright calcium flocculi. Measures of the two components of H_2 and K_2 are made with greater difficulty, but these also seem to show that the calcium vapor is rising in the flocculi, at a velocity which ordinarily does not differ greatly from about one kilometer per second. Hitherto we have not had an opportunity to investigate the motions in certain special regions of the flocculi, toward which our attention has been directed by some of the phenomena shown in the photographs corresponding to different levels.

In concluding, we may perhaps be permitted to speak of a few of the numerous investigations which can be undertaken by the student of solar physics. If proper use is to be made of the numerous methods of research which are now available, a large number of investigators will be needed, working, if possible, on some co-operative plan, at many stations widely separated in longitude. Even the adequate use of the spectroheliograph alone would be beyond the capacity of any single institution; for, when suitably designed, this instrument will furnish as many photographs of the Sun as there are elements present in its atmosphere, and, in addition to these, many others which represent the peculiarities of certain lines. For example, we have already seen that it will be desirable to ascertain in what degree photographs taken with enhanced lines differ from those taken with other lines of the same element. With a large image of the Sun important results might be expected to follow from a study of photographs of Sun-spots taken with the aid of the widened lines, and with bright lines or other lines which are peculiar to the spot. In view of the constant changes which are going on in the Sun, a few photographs made in any of these ways will not suffice: what is wanted are series continued through at least one Sun-spot period, in order to discover the laws which govern the intensity and the distribution of the various gases and metallic vapors. Furthermore, the great importance of eruptive phenomena, their comparative rarity, and the brief time in which all their phases are exhibited, call for special preparations and methods of work. Spectroheliographs capable of taking several photographs at once through different lines will be essential for any suitable study of eruptive phenomena. If a chain of observatories well distributed in longitude could arrange their work so as to keep the Sun almost constantly under observation, many important eruptions which are now lost would be recorded.

But it is by no means sufficient merely to take photographs of the Sun with the spectroheliograph. In order to extend greatly the range of the attack, and also to explain the spectroheliograph results, [illegible] bservations, both visual and photographic, with other instruments are essential. For [illegible]ple, while a photograph is being taken with the spectroheliograph, exposures on the spectrum of the region under investigation, for the purpose of showing the widened lines in Sun-spots as well as the motions in the line of sight of the calcium vapor in the flocculi, should be provided for. These must be made with an instrument of sufficient dispersion to permit the photographs to be measured with high precision. At the same time, large scale photographs of the photosphere and spots, made [illegible] are needed for comparison with the spectroheliograph results. Many [illegible] are required — and numerous other investigations which will suggest

themselves to the reader. The essential point is that a *simultaneous* attack should be made on solar phenomena with a series of powerful instruments, each designed to answer definite questions, and thus to furnish some of the material that will be required for solving solar problems.

But such an attack, comprehensive as it might be made, would be greatly hampered if the atmospheric conditions were not favorable. The difference between the effects of good and bad seeing may be seen by comparing the blurred photograph reproduced in Fig. 1, Plate VII, which was the best that could be obtained at the time, with the (larger scale) photograph reproduced in Fig. 3, Plate IV, which was made with precisely the same instruments and adjustments at a time when the conditions were unusually good. If such conditions as these latter could be had day after day for long periods of time, with occasional periods of even finer definition, many questions now out of reach could be solved.

A report on the instrumental and atmospheric conditions needed in future work on the Sun may be found in the forthcoming *Year Book* (No. 2) of the Carnegie Institution.

OCTOBER, 1903.

DESCRIPTION OF THE PLATES

PLATE I

The Rumford spectroheliograph, attached to the forty-inch Yerkes refractor. The shaft which is driven by the declination motor may be seen at the right. It carries a grooved pulley near its lower end, connected with a similar pulley at the end of the camera box by means of a round leather belt. On the same shaft with this second pulley is a spur gear, which engages with the two gears on the projecting ends of the screws that pass through the camera box. The keys used to operate the split-nuts that clamp the plate-carriage to the screws, the windows for observing the spectrum at the middle and at the ends of the second slit, and the screw-drivers employed to push forward the plate-holder after the slide is withdrawn, are on the top of the camera box. At the left end of the box may be seen the door through which the plate-holder is inserted, and the narrow sliding door in its outer face through which the slide is withdrawn, as well as the micrometer heads of the screws for controlling the width of the second slit and for moving it as a whole. The first slit, at the end of the collimator, is almost hidden from view by the metallic screen required to shield its mounting from the great heat of the solar image. Light reaches the first slit through a long narrow opening in this screen. Mounted on four posts above the screen, at such a height as to lie in the visual focal plane when the first slit is at the focus for the K line, is a narrow metallic plate, on which a line is drawn in the direction of dispersion. During an exposure, the limb of the Sun is made to follow this line. At the end of the electric cable may be seen the switches used for operating the declination motor, and (just below) the rod with which the mirror in the prism box is rotated. The interior of the prism box is shown in Fig. 1, p. 8.

PLATE II

FIG. 1.—Full-size reproduction of a photograph of the H and K lines in the solar spectrum, made with the curved first slit. The two curved slits regularly employed with the spectroheliograph to eliminate distortion of the solar image have a radius of 522 mm, equal to that of the curved lines here shown.

FIG. 2.—The K line on the solar disk and in the chromosphere at the limb (radial slit). The bright reversals (K_2) are due to the flocculi. Where faculæ are present the continuous spectrum is more or less strengthened.

FIG. 3.—H and K lines on the solar disk and in the chromosphere (radial slit).

FIG. 3*a*.—Shows H_3 and K_3 (very faintly) in a prominence.

FIG. 4.—Reversals of the H and K lines in the electric arc, showing the decrease in width from the inner (dense) to the outer (rare) calcium vapor.

Fig. 5.—Minute calcium flocculi, resembling the granulation of the photosphere. The squares are 10″ of arc on a side.

PLATE III

Entire disk of the Sun, as photographed 1903, August 12, $8^h\ 52^m$ C.S.T. with the H_2 line. Same size as original negative. The squares of the half-tone screen are too coarse to permit the smallest details to be shown.

PLATE IV

FIG. 1.—One-level (H_1) centers of calcium flocculi, showing how these flocculi appear to be made up of vertical columns of calcium vapor.

FIG. 2.—High-level (H_2) centers of the same flocculi, showing faintly how the vapor columns seem to be [illegible] as the outside are well separated.

FIG. 3.—Minor calcium flocculi (H_1 level), showing their normal appearance under excellent conditions of seeing.

PLATE V

FIG. 1.—For this photograph the second slit was set on the continuous spectrum at λ 3924. Consequently [illegible] flocculi, though the [illegible] faintly visible. The forms of the latter should be compared with those of the flocculi in the other figures.

FIG. 2.—Low K_1 level. Slit set at λ 3929. This shows the dense calcium vapor not far above the photosphere. Compare with Fig. 1, and note that even at this low level the calcium vapor overhangs, and sometimes completely covers small spots.

FIG. 3.—Higher K_1 level. Slit at λ 3932. Though taken before the photographs reproduced in Figs. 1 and 2, this picture further emphasizes the differences noted at lower levels. The fact that the changes are progressive largely eliminates the time element, which might otherwise be suspected of causing the observed differences. As a matter of fact, these flocculi are quiescent and slowly changing, differing very decidedly from eruptive phenomena.

FIG. 4. K_2 level. Slit at λ 3933.8. Here the calcium vapor is very brilliant, and covers a larger area. The photograph contains distinct evidence of dark absorbing masses at higher levels. Perhaps the best instance of this is the dark tongue which runs somewhat north of west from the small spot south preceding the largest one of the group. This tongue seems to form a part of an extensive dark area, which completely surrounds the bright flocculi of the group.

PLATE VI

A series of photographs, similar to those in Plate V, showing the changes in the calcium flocculi at different levels above the photosphere. In Fig. 4 evidences may be seen of dark flocculi due to absorbing vapors at higher levels.

PLATE VII

FIG. 1. Small bright flocculus at region where the spot group appeared later. This photograph was taken when the seeing was very poor, and when compared with such a photograph as that in Fig. 3, Plate IV, serves as an excellent illustration of the importance of good seeing.

FIG. 2.—The same region one day later.

FIG. 3.—The same region on the following day, showing the calcium vapor at the H_2 level.

FIG. 4. Photograph of the low-lying H_1 vapor corresponding to Fig. 3.

PLATE VIII

FIG. 1.—Calcium flocculi surrounding a spot when near the east limb of the Sun. The strong dark regions in this photograph are due to too great contrast in the original, and not to dark calcium flocculi.

FIG. 2.—The same region about six hours later, as photographed with the *Hβ* line. Near the spot the hydrogen immediately surrounding the spot appears to be bright, while an extensive dark hydrogen flocculus lies to the east [illegible] approximately the same region as that of the bright calcium flocculus.

It should be noted that all the photographs of hydrogen flocculi are slightly distorted, owing to the fact that a straight first slit and a curved second slit are used with the grating.

FIG. 3.—Dark calcium flocculus, corresponding to the exceptionally dark hydrogen flocculus shown in Fig. 1, which represents the same region of the Sun. The contrast in Fig. 3 is rather too great, and some regions which might seem to resemble dark flocculi should appear much lighter.

PLATE IX

FIG. 1.—[illegible] to the east the contrast is too great in this photograph, and the appearance of the [illegible] exposure. In reality the dark masses in general represent the hydrogen flocculi, though [illegible] a few [illegible] the spot group bright flocculi are present.

FIG. 2.—The [illegible] this photograph, is more nearly what it should be, though the [illegible] in [illegible] Here [illegible] typical example of bright hydrogen flocculi may be seen to the west of the spot, [illegible] [illegible] at the time.

FIG. 3. This cut represents more nearly the appearance of the dark hydrogen flocculi on the negatives. As the slit did not coincide with the $H\beta$ line throughout its length, the flocculi are not shown to the west of the spot. A small bright flocculus may be seen at the extreme edge of the figure on the left, adjoining the small spot.

FIG. 4.—The contrast here is rather too great, and for this reason the background appears too dark. The general character of the bright calcium flocculi is nevertheless fairly well shown. The bright tongue extending into the small spot on the left is eruptive in character, and corresponds with the bright hydrogen flocculus referred to in the description of Fig. 3.

PLATE X

FIG. 1.—Low-level photograph, showing the dense calcium vapor lying just above the photosphere. In this photograph very little of the penumbra is covered by the calcium vapor, but evidences may be seen, especially in the southern part of the penumbra of the largest spot, of the columns of vapor which are greatly developed at the higher levels.

FIG. 2.—In this photograph the calcium vapor is much better shown than in Fig. 1, and the beginnings of eruptive phenomena have become more distinctly evident.

It is to be understood that although the changes going on in the eruptive phenomena of the spot group prevent a perfect comparison of all the details of the successive photographs in this and the subsequent series, the large masses of flocculi change so slowly in form that they may be compared without danger of serious error. In general, the differences between the successive pictures are therefore due to differences in the extent and brightness of the vapor at different levels, rather than to changes in form which have taken place between exposures. In order to render possible a satisfactory comparison of the high- and low-level flocculi surrounding this spot, the matched pair of photographs, reproduced in Plate XV, is given for examination with the stereoscope.

PLATE XI

FIG. 1.—This photograph, which represents the high-level calcium vapor, should be compared with Figs. 1 and 2, Plate X. It will be seen that at this level the penumbra is almost completely covered, while many of the smaller spots are blotted out. There are also distinct evidences of dark flocculi, due to absorbing vapors at still higher levels. The illustration necessarily fails to indicate the brilliancy of the brightest eruptive phenomena, which on the original negatives are easily distinguished from the ordinary flocculi.

FIG. 2.—This photograph, which shows the hydrogen flocculi surrounding the spot group, should be compared with Fig. 1. The brighter regions are in most cases eruptive. In general, the hydrogen flocculi in the less disturbed regions are dark, though they may perhaps be bright or neutral where they overhang the penumbra, and cover some of the smaller spots of the group.

PLATE XII

The photographs reproduced in this plate represent the low- and medium-level flocculi surrounding the spot group, as they appeared on October 10. The changes in the group may be seen by comparing these photographs with those given in Plate X.

PLATE XIII

FIG. 1.—The difference in level between Fig. 2, Plate X, and Fig. 1, Plate XI, is too great to permit of a satisfactory study of the changes in form of the flocculi at different heights above the photosphere. In the present series it is fortunately possible to give an intermediate step, obtained by setting the second slit immediately outside of H_2; the level shown therefore lies between that of Fig. 2, Plate XII, and that of Fig. 2, Plate XIII.

FIG. 2.—This photograph, although the same as that reproduced in Plate XIV, is given here in the endeavor to bring out the bright eruptive tongues, which in Plate XIV are hardly to be distinguished from the less brilliant flocculi. The abnormally dark background necessarily results from the deep printing required to show the exceedingly brilliant details. For a general view of the flocculi at this level reference must be made to Plate XIV.

PLATE XIV

This photograph belongs to the same series reproduced in Plates XII and XIII. It represents the high-level calcium vapor photographed with the H_2 line, and is made from the same negative reproduced in Fig. 2, Plate XIII. By comparing this plate with Fig. 1, Plate XIII, the presence of dark flocculi, due to absorbing vapors at higher levels, may be noticed. It should be remarked that a slight swaying of the telescope at the moment when the north preceding spot of the group was passing over the slit of the spectroheliograph has produced a certain small distortion of the details, in a narrow band extending through the small spot in the upper part of the figure.

PLATE XV

In comparing the photographs corresponding to different levels a double stereopticon is used, by which two negatives can be projected upon a screen, where the images are exactly superposed. The method has proved so instructive that it has seemed desirable to provide with this paper a simple means of accomplishing the same result. Accordingly a pair of high- and low-level photographs has been arranged for use with the stereoscope. It is to be understood that no stereoscopic effect in the ordinary sense will be obtained in examining these photographs. The purpose of using the stereoscope is merely to allow the images to be superposed, thus permitting them to be seen at the same point in rapid succession by quickly moving a card so as to cover alternately the two lenses of the stereoscope. In this way the same region of the Sun may be examined, first as it appears at the low level of the denser calcium vapor, and then as it appears at the higher level of the rarer vapor. Thus the manner in which the calcium flocculi overhang the penumbra, and sometimes the umbra of spots, and the absence at the lower level of the dark structures shown in certain parts of the high-level picture, can be observed. This method of comparison also gives an excellent means of detecting small changes in the form of the flocculi, as shown by photographs corresponding to the same level, but taken at different times.

PLATE II

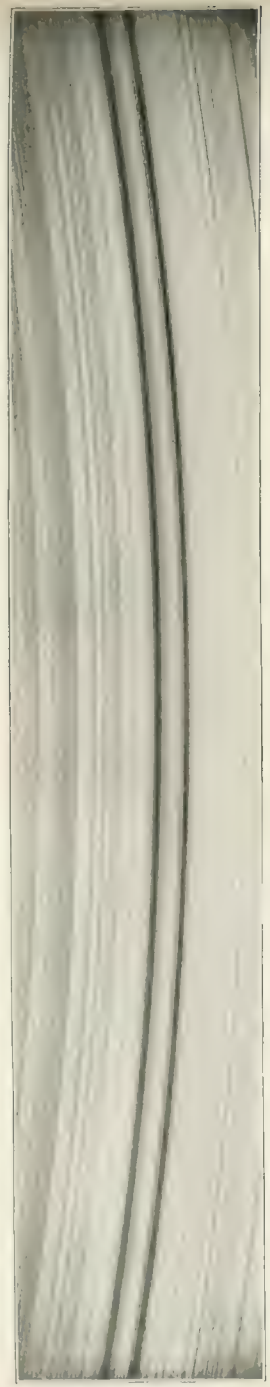


Fig. 1. Curvature of Lines in the Spectroheliograph

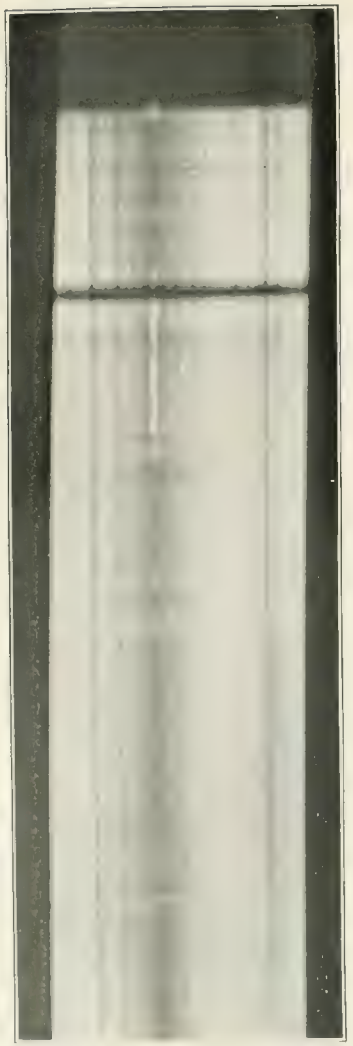


Fig. 2. K Line on the Disk and at the Limb

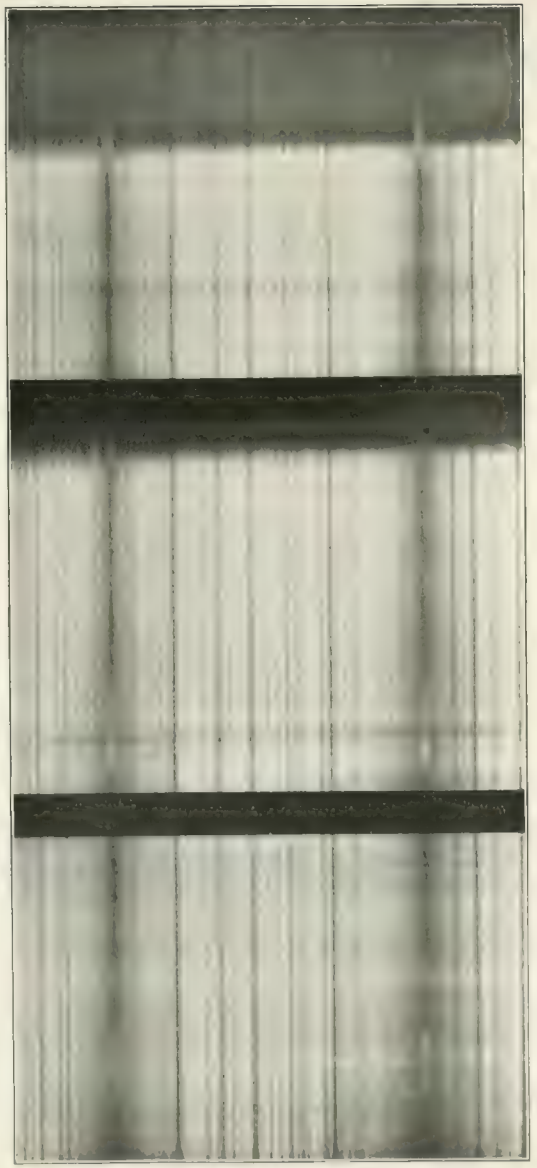


Fig. 3. H and K Lines on the Disk, in the Chromosphere, and in a Prominence (a)

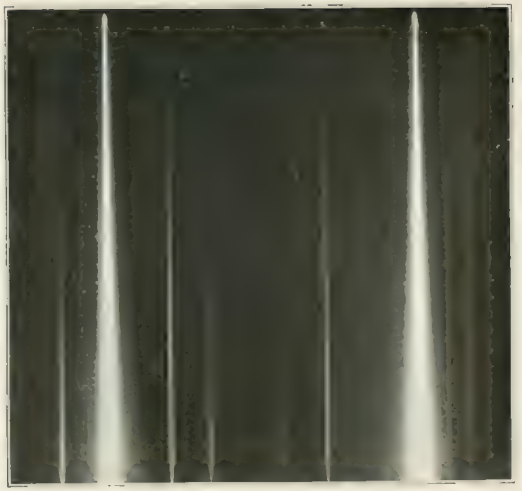


Fig. 4. H and K Lines in Electric Arc Showing Reversals

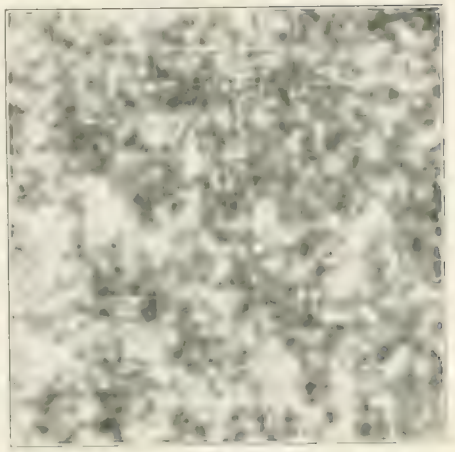


Fig. 5. Minute Calcium Flocculi (H$_2$) The Spectrograph 10 on a Side

PLATE III

N

E W

S

THE SUN, SHOWING THE CALCIUM FLOCCULI (H_2 LEVEL). 1903, AUGUST 12, $8^h\,52^m$. C. S. T.

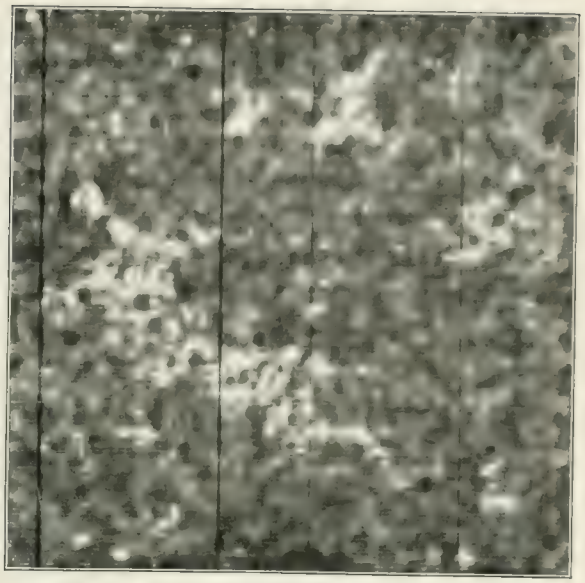


FIG. 1. $3^h 40^m$. LOW H_1 LEVEL
Slit at λ3962

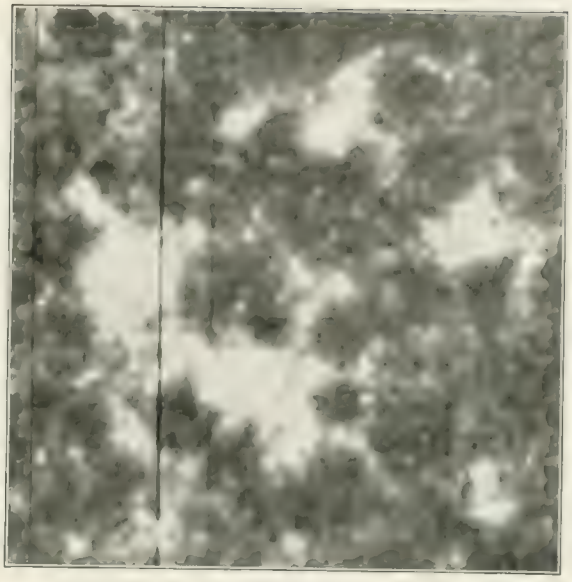


FIG. 2. $3^h 31^m$. H_2 LEVEL
Slit at λ3968.6. Same Region as FIG. 1

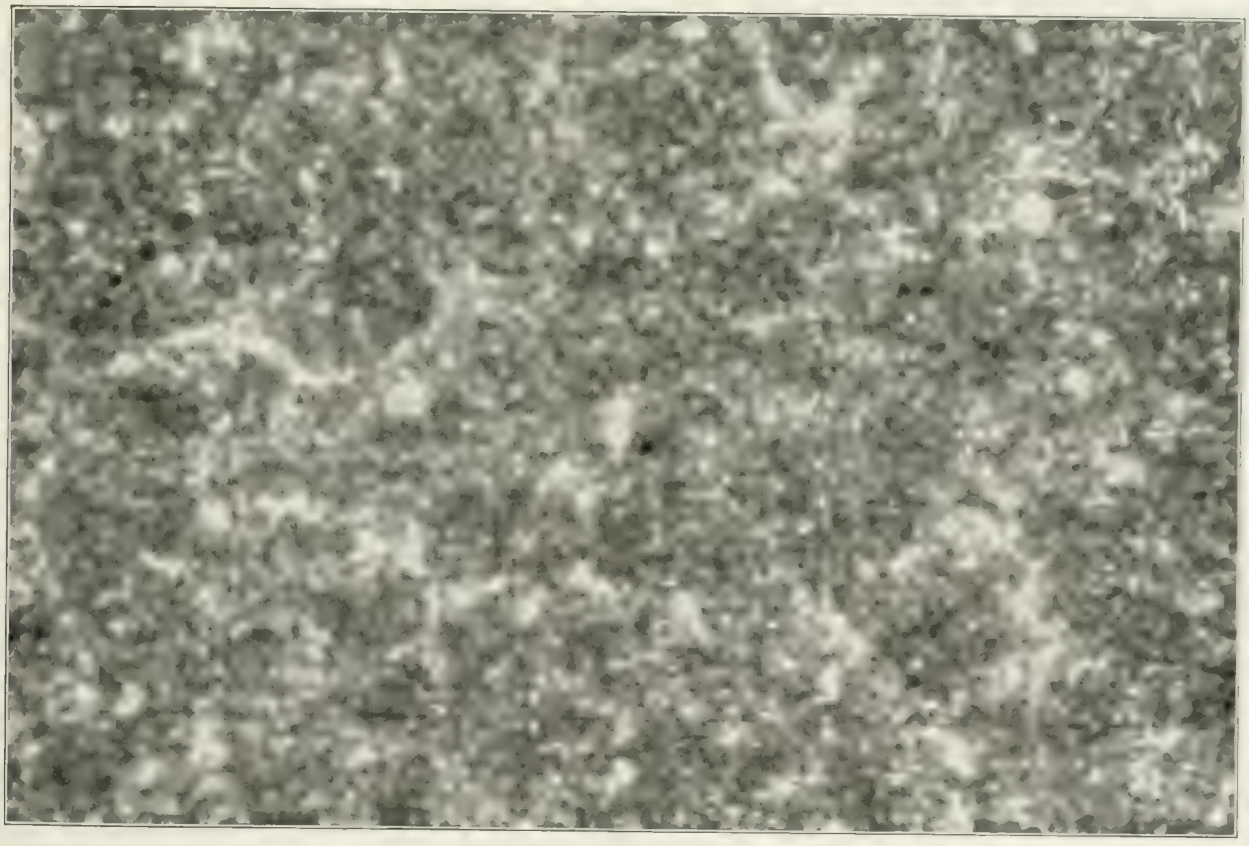
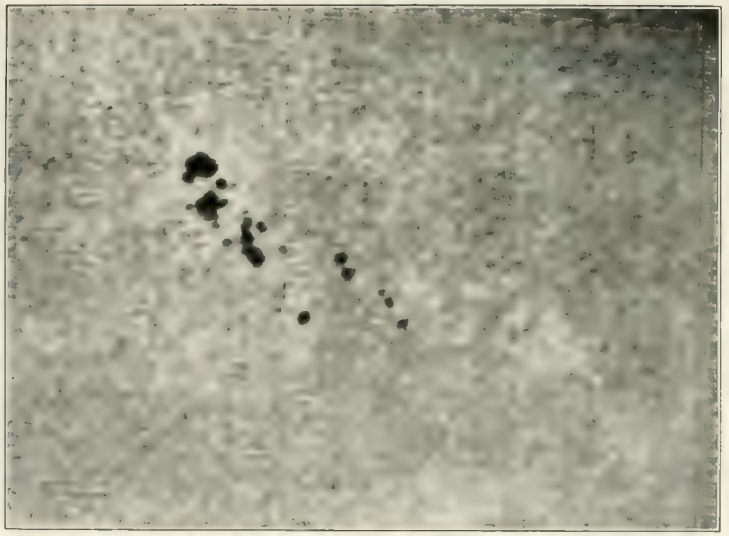


FIG. 3. $3^h 31^m$. GENERAL APPEARANCE OF SUN'S DISK AT H_2 LEVEL

MINUTE STRUCTURE OF THE CALCIUM FLOCCULI, 1903, SEPTEMBER 22
Scale: Sun's Diameter = 0.890 Meter

PLATE V

N



E

FIG. 1. $11^h 32^m$. FACULÆ
Slit on Continuous Spectrum at λ 3924

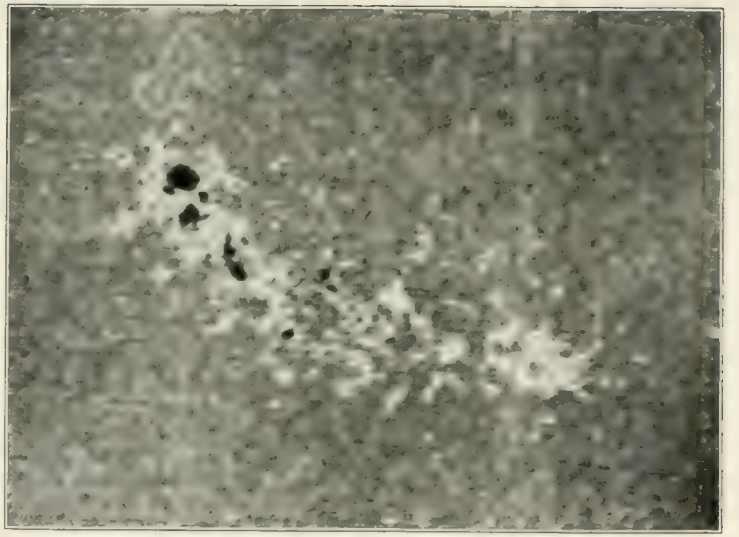


FIG. 2. $11^h 22^m$. CALCIUM FLOCCULI, LOW K_1 LEVEL
Slit at λ 3929

W

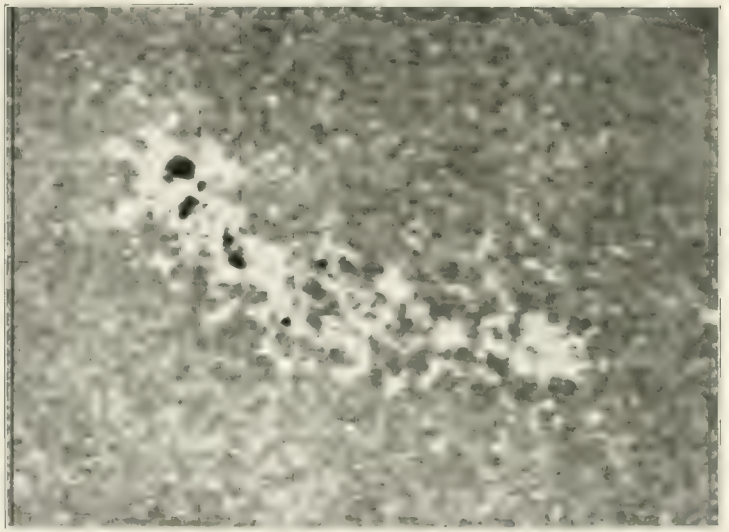


FIG. 3. $10^h 28^m$. CALCIUM FLOCCULI, HIGHER K_1 LEVEL
Slit at λ 3932

S

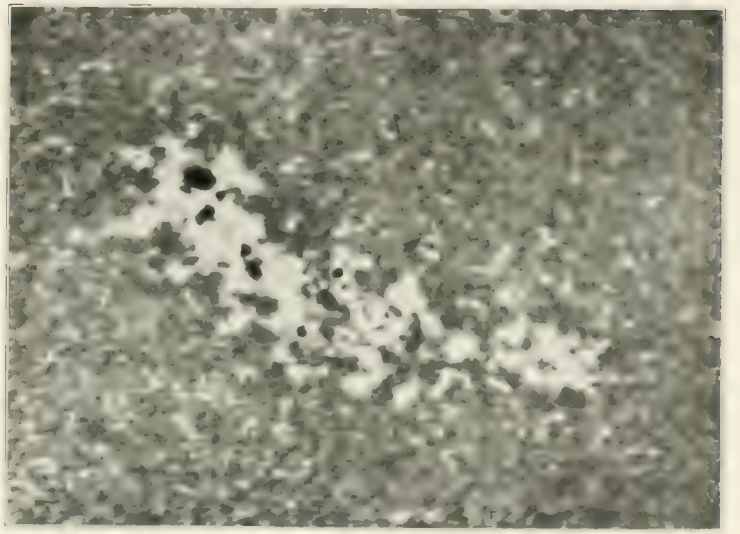


FIG. 4. $11^h 11^m$. CALCIUM FLOCCULI, K_1 LEVEL
Slit at λ 3933.8

FACULÆ AND SECTIONS OF CALCIUM FLOCCULI AT DIFFERENT LEVELS, 1903, APRIL 29
Scale: Sun's Diameter = 0.280 Meter

N

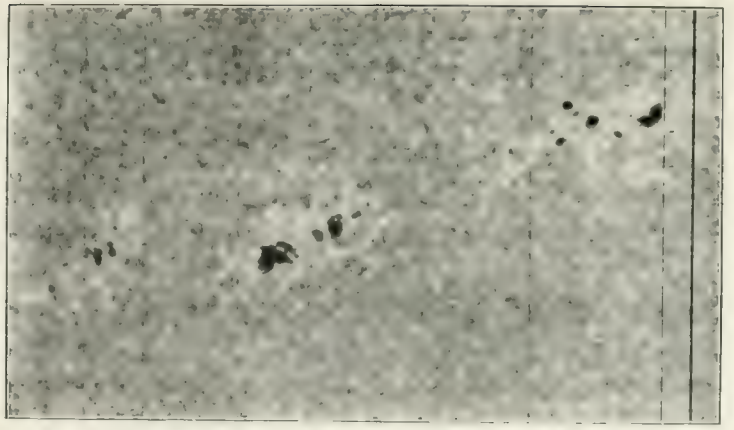


FIG. 1. 3h 47m. FACULE
Slit Set on Continuous Spectrum at λ 3921

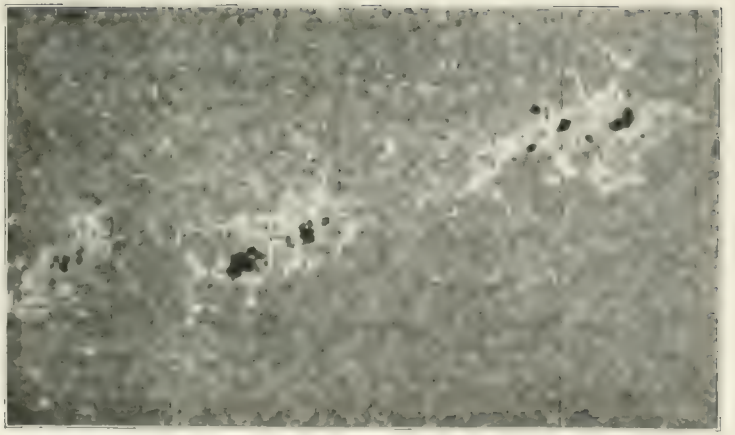


FIG. 2. 4h 0m. CALCIUM FLOCCULI, LOW K_1 LEVEL
Slit at λ 3929

E W

FIG. 3. 3h 55m. CALCIUM FLOCCULI, HIGHER K_1 LEVEL
Slit at λ 3932

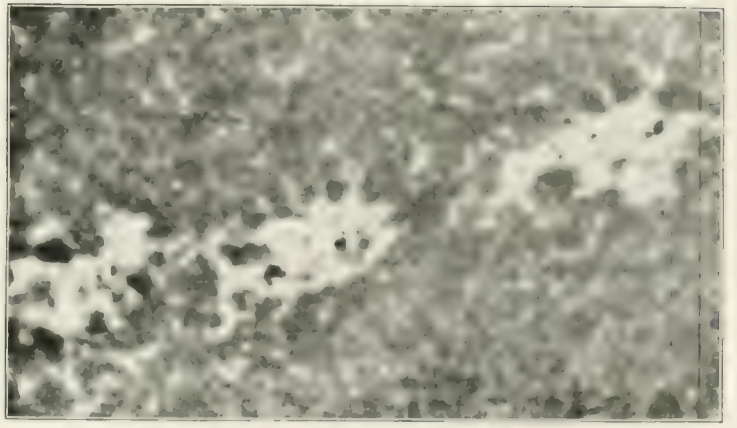


FIG. 4. 4h 06m. CALCIUM FLOCCULI, K_1 LEVEL
Slit at λ 3933.8

S

FACULE AND SECTIONS OF CALCIUM FLOCCULI AT DIFFERENT LEVELS, 1903, AUGUST 10
Scale: Sun's Diameter = 0.295 Meter

PLATE VII

N

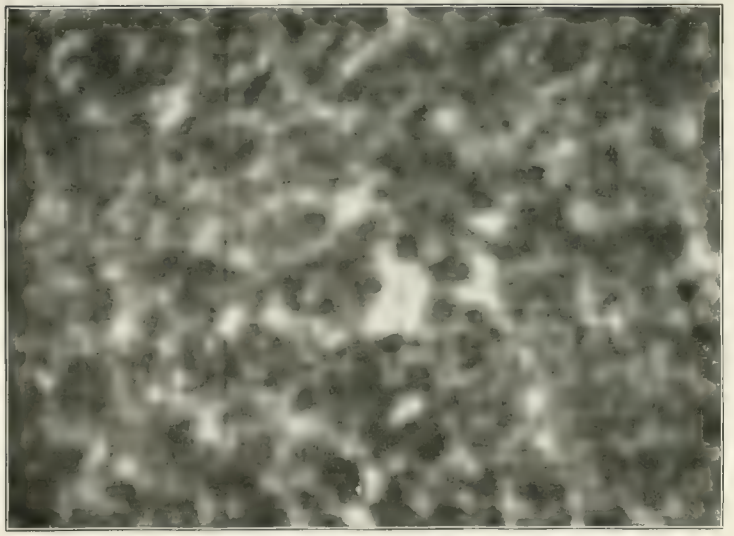


FIG. 1. JULY 23, 10h 19m. HIGH LEVEL
Slit Set on K_2 (λ3933.8)

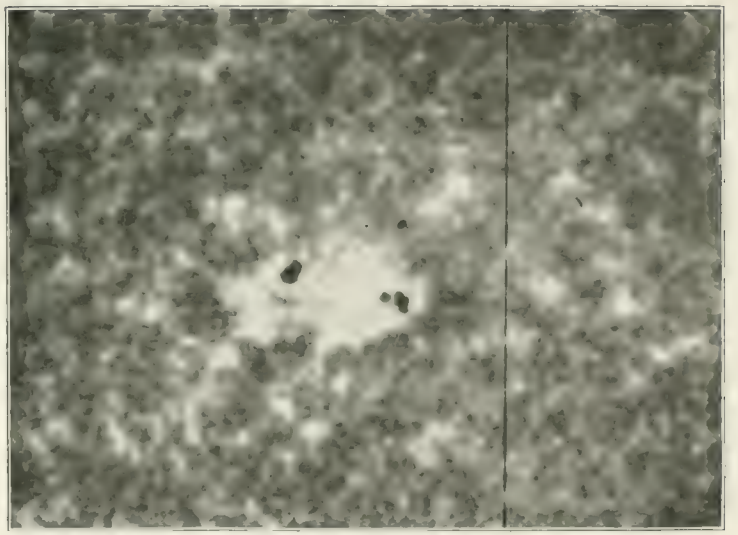


FIG. 2. JULY 24, 9h 27m. HIGH LEVEL
Slit Set on H_2 (λ3968.6)

E W

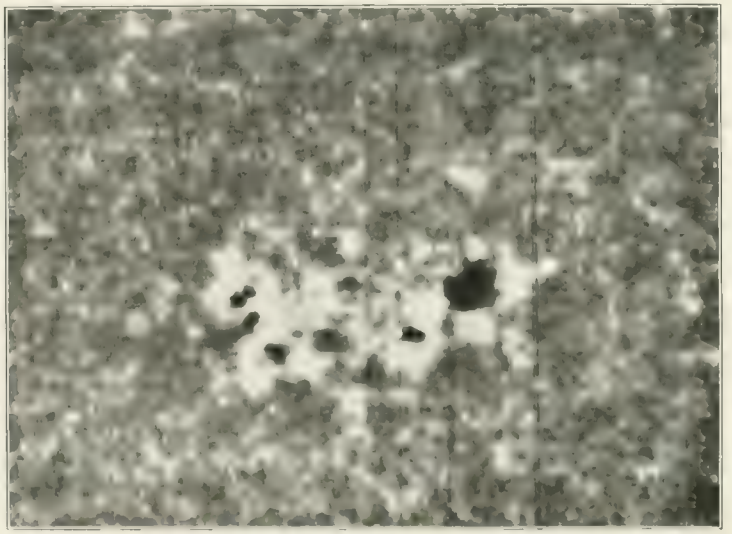


FIG. 3. JULY 25, 9h 26m. HIGH LEVEL
Slit Set on H_2 (λ3968.6)

S

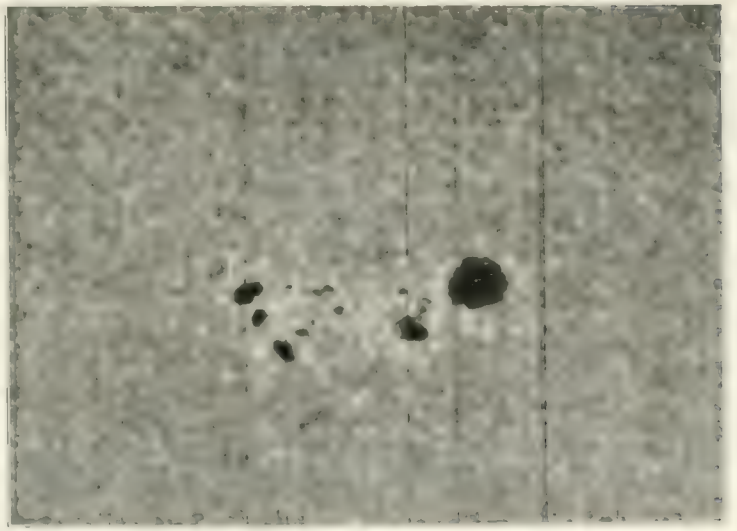


FIG. 4. JULY 25, 8h 52m. LOW LEVEL
Slit Set on H (λ3962)

RAPID DEVELOPMENT OF SPOT GROUP AND CALCIUM FLOCCULI
Scale: Sun's Diameter = 0.680 Meter

PLATE VIII

N

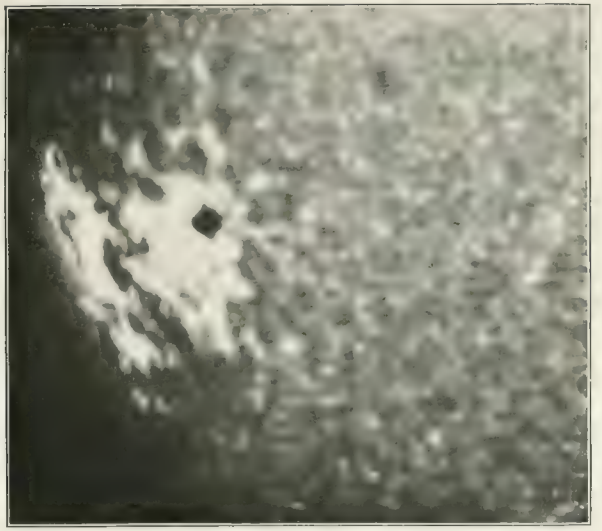


FIG. 1. JULY 2, 9h 39m. CALCIUM FLOCCULI, K_2 LEVEL
Slit at λ3933.8

E

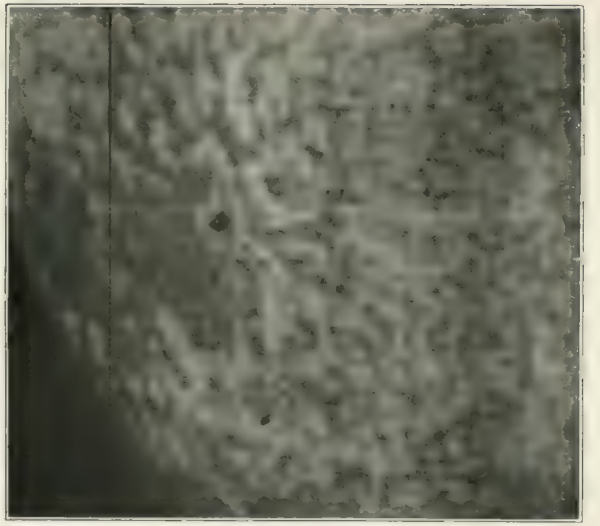


FIG. 2. JULY 2, 3h 40m. HYDROGEN FLOCCULI
Slit at Center of *H3*

W

Scale: Sun's Diameter = 0.335 Meter

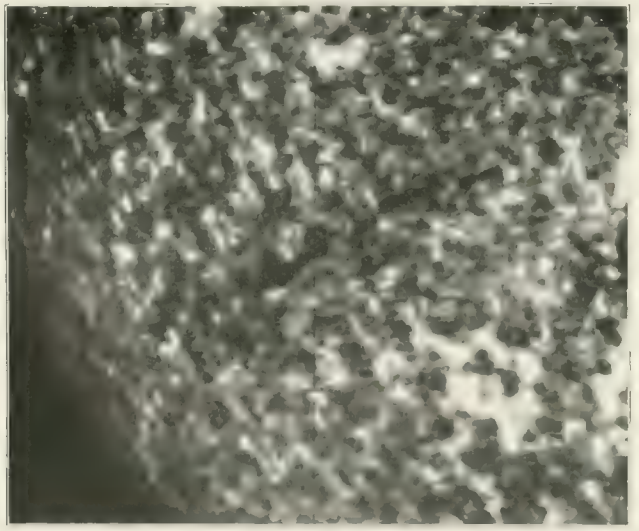


FIG. 3. JUNE 17, 9h 08m. DARK CALCIUM FLOCCULUS
Slit at λ3933.8

S

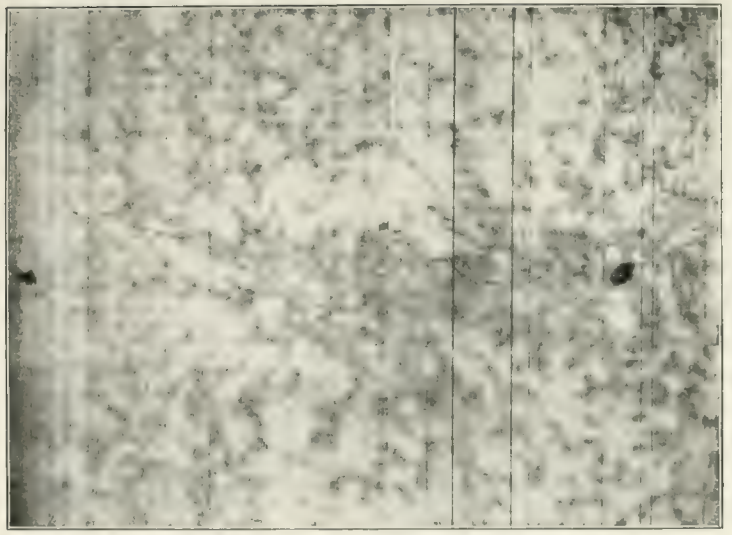
FIG. 4. JUNE 17, 10h 18m. STRONG HYDROGEN FLOCCULUS
Slit at Center of *H3*. (Compare with Fig. 3)

Scale: Sun's Diameter = 0.350 Meter

COMPARISON OF CALCIUM AND HYDROGEN FLOCCULI

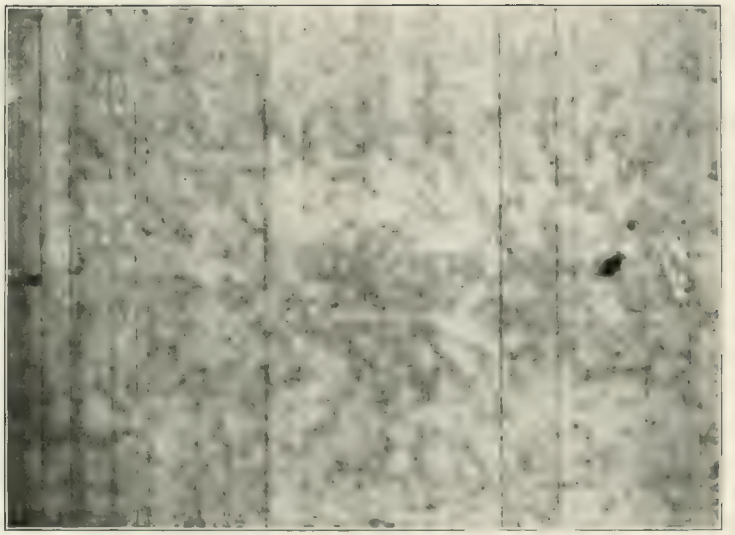
PLATE IX

N



E

FIG. 1. $9^h 39^m$. HYDROGEN FLOCCULI
Slit at Center of $H\beta$



W

FIG. 2. $11^h 0^m$. HYDROGEN FLOCCULI
Slit at Center of $H\gamma$. (Bright eruptive flocculi west of spot)

FIG. 3. $2^h 50^m$. HYDROGEN FLOCCULI
Slit at Center of $H\beta$

S

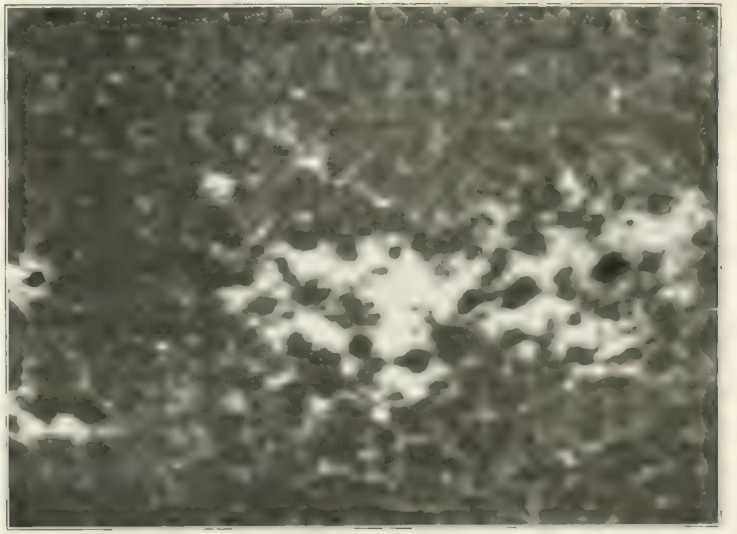


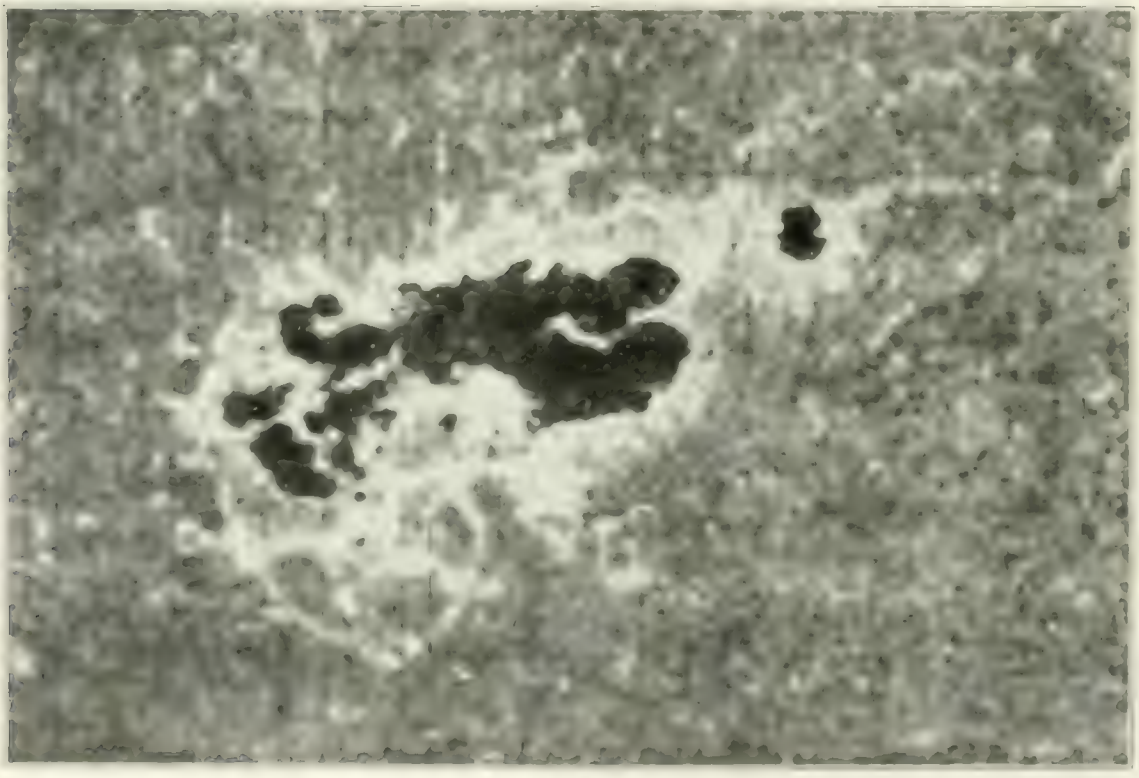
FIG. 4. $3^h 57^m$. CALCIUM FLOCCULI, K$_3$ LEVEL
Slit at $\lambda 3933.8$

HYDROGEN AND CALCIUM FLOCCULI, 1903, JULY 7
Scale: Sun's Diameter = 0.290 Meter

N

FIG. 1.—Oct 9, 3h 42m. CALCIUM FLOCCULI, LOW H LEVEL.
Slit at λ3962

E W



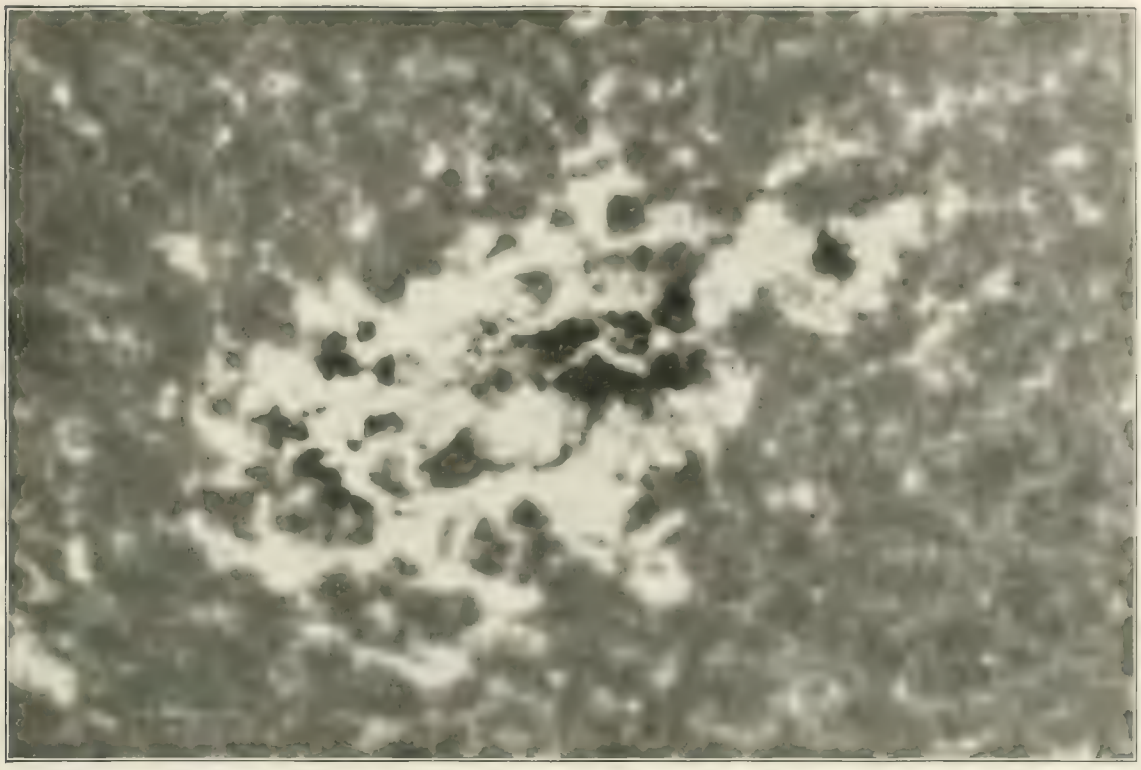
S

FIG. 2.—Oct 9, 3h 41m. CALCIUM FLOCCULI, MIDDLE H LEVEL.
Slit at λ3968

THE GREAT SUN SPOT OF OCTOBER 1903
Scale—Sun's Diameter = 0.350 Meter

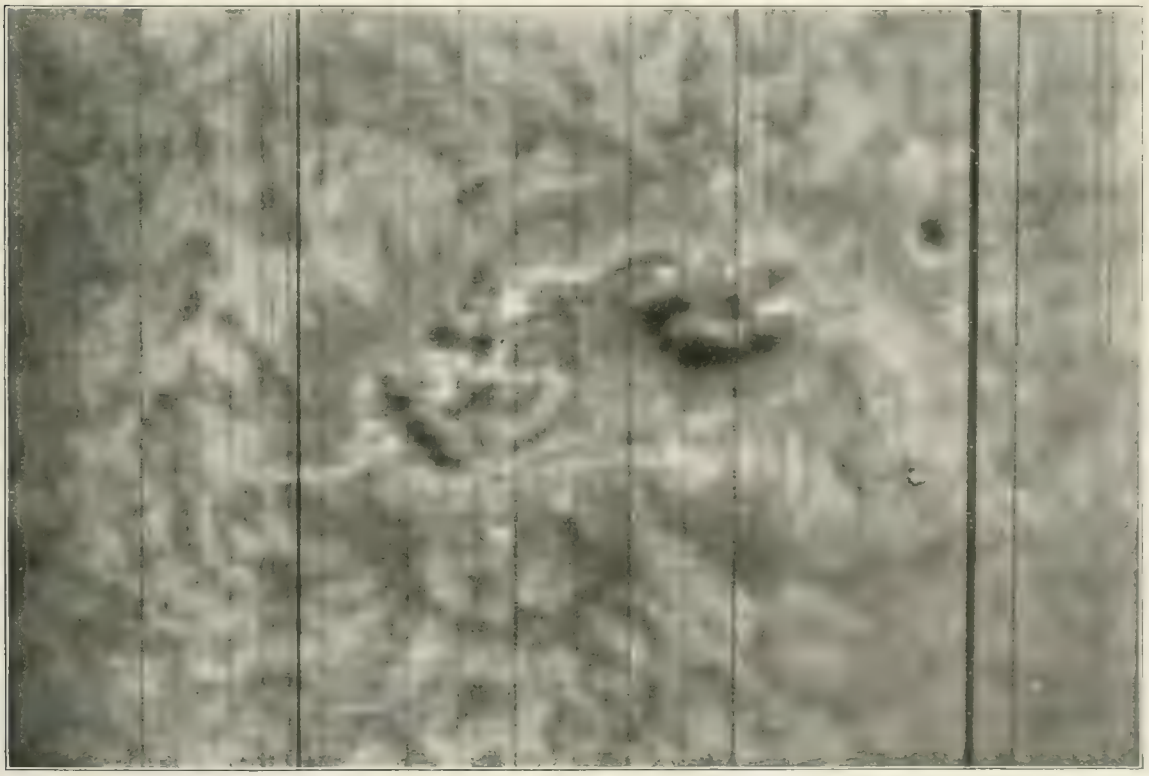
PLATE XI

N



E W

FIG. 1. OCT. 9, 3h 30m. CALCIUM FLOCCULI, H_1 LEVEL
Slit at λ3968.6



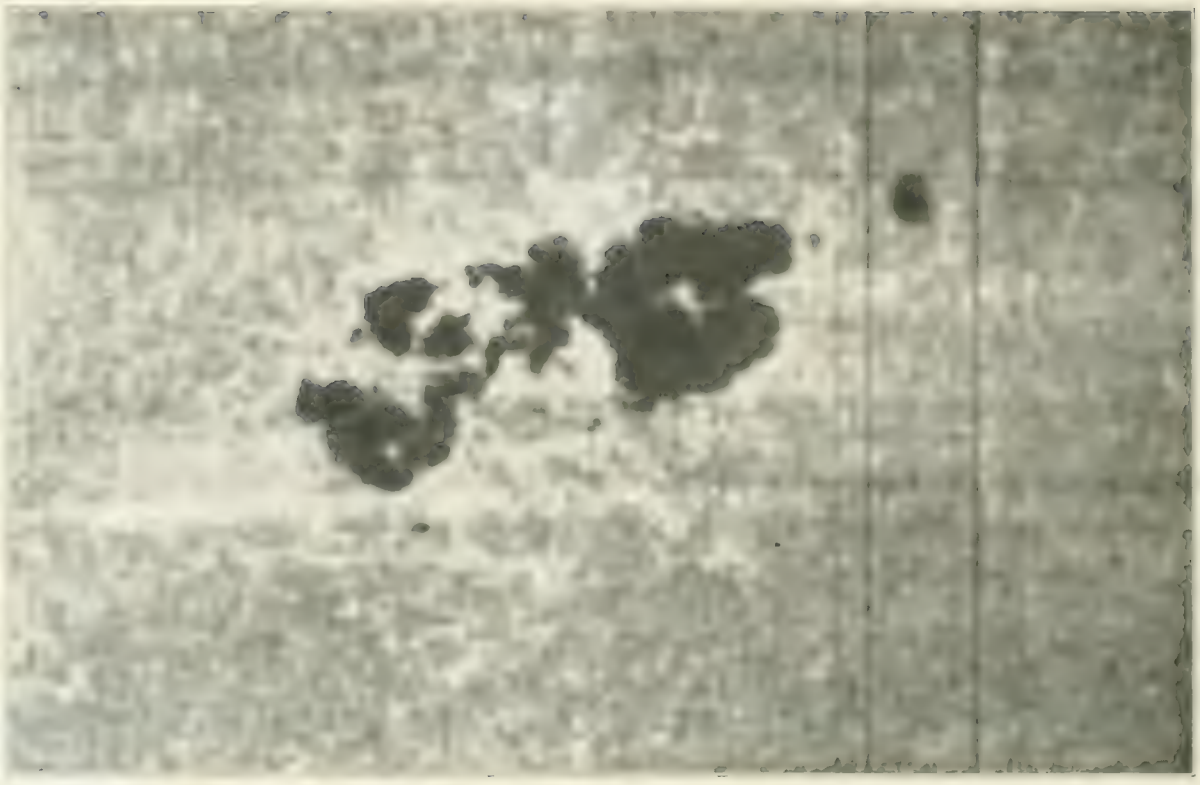
S

FIG. 2. OCT. 9, 1h 04m. HYDROGEN FLOCCULI
Slit Set on $H\beta$

THE GREAT SUN-SPOT OF OCTOBER, 1903
Scale: Sun's Diameter = 0.550 Meter

PLATE XII

N



E

W

Fig. 1.—Oct. 19, 8h 58m. Calcium Flocculi, Low H Level.
Slit at λ 3962

S

Fig. 2.—Oct. 19, 9h 00m. Calcium Flocculi, Mount H Level.
Slit at λ 3962.

THE GREAT SUN-SPOT OF OCTOBER, 1903.

PLATE XIII

N

E

FIG. 1. OCT. 10, $10^h 59^m$. CALCIUM FLOCCULI, HIGH H_1 LEVEL
Slit at λ3967.5

W

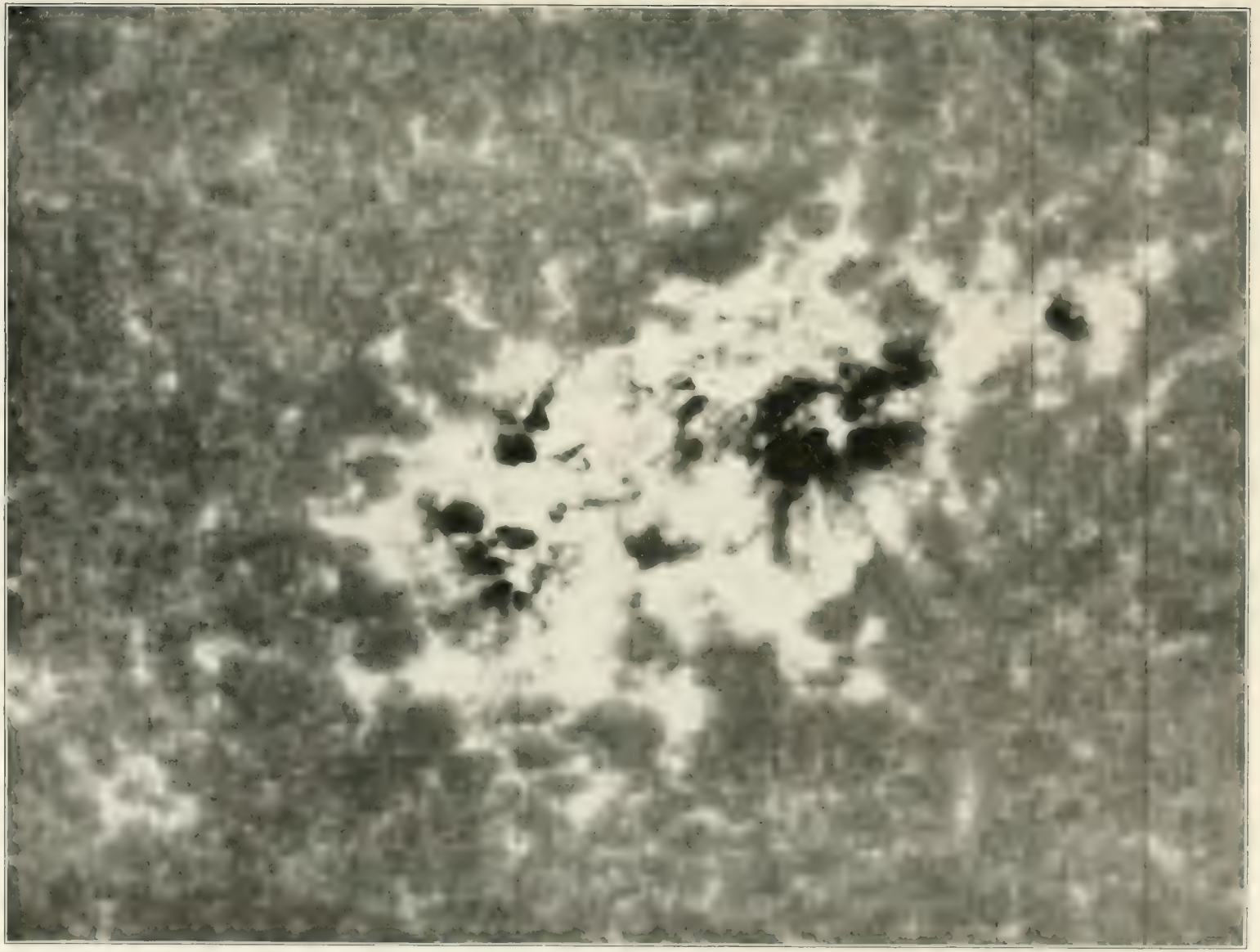
S

FIG. 2. OCT. 10, $9^h 09^m$. CALCIUM FLOCCULI, H_2 LEVEL
Slit at λ3968.6

THE GREAT SUN-SPOT OF OCTOBER, 1903
Scale: Sun's Diameter = 0.565 Meter

PLATE XIV

N

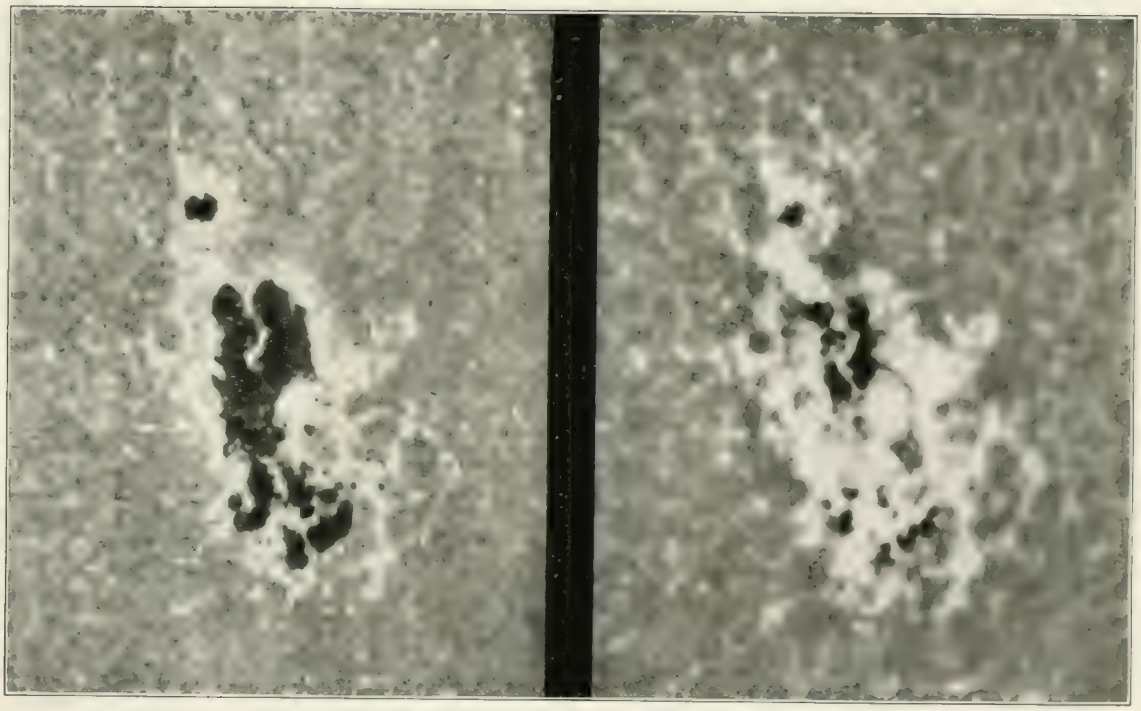


E W

S

THE GREAT SUN-SPOT OF OCTOBER, 1903. CALCIUM FLOCCULI. H_2 LEVEL

Slit at λ3968.6. October 10, 9h 09m. Scale: Sun's Diameter = 0.725 Meter



Oct. 9, 3h 43m. Calcium Flocculi, Middle H_1 Level
Slit at λ 3966

Oct. 9, 3h 30m. Calcium Flocculi, H_2 Level
Slit at λ 3968.6

THE GREAT SUN-SPOT OF OCTOBER, 1903
For Comparison with the Stereoscope

THE UNIVERSITY OF CHICAGO
FOUNDED BY JOHN D. ROCKEFELLER

PUBLICATIONS OF THE YERKES OBSERVATORY

VOLUME III PART II

THE SPECTRUM OF THE HIGH POTENTIAL DISCHARGE BETWEEN METALLIC ELECTRODES IN LIQUIDS AND IN GASES AT HIGH PRESSURES

BY

GEORGE E. HALE
AND
NORTON A. KENT

CHICAGO
THE UNIVERSITY OF CHICAGO PRESS
1907

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THE SPECTRUM OF THE HIGH POTENTIAL DISCHARGE BETWEEN METALLIC ELECTRODES IN LIQUIDS AND IN GASES AT HIGH PRESSURES

By George E. Hale and Norton A. Kent

INTRODUCTION

In February, 1901, shortly after the appearance of *Nova Persei*, experiments were undertaken in the spectroscopic laboratory of the Yerkes Observatory, in the hope that some light might be thrown upon the phenomena of temporary stars. It seemed desirable to repeat the important experiments of Wilsing, whose work on the spectrum of the high potential discharge between metallic poles in liquids had led him to propose a new theory to account for these abnormal celestial outbursts. Prior to the work of Wilsing the presence in the spectra of temporary stars of compound lines, having a bright component toward the red and a dark one toward the violet, had usually been accounted for as a result of Doppler's principle. It was supposed that the sudden outburst of light had arisen from the collision of two bodies moving with enormous velocities in the line of sight. The approaching body was supposed to give a spectrum of dark lines and the receding body a spectrum of bright lines. Thus in the integrated light of the two there should appear compound lines similar to those observed in *Nova Aurigae*. It was recognized, however, that this hypothesis was not without difficulties, which were greatly increased later when the spectrum of *Nova Normae* was found to resemble closely that of *Nova Aurigae*, and when it was recognized that the spectrum of *P Cygni* (the *Nova* of 1600) was characterized by similar pairs of lines. In all cases the dark lines were the more refrangible and the bright lines the less refrangible members of the pairs, while the velocities corresponding to their relative displacements were far in excess of the velocities of any celestial objects ever observed with the spectroscope. It was also a noteworthy fact that the distance between the lines, and consequently the corresponding relative velocities of the stars, underwent no important change during the period of visibility.

Subsequent to the publication of Wilsing's first paper, and prior to the outburst of *Nova Persei*, it had been generally recognized that the compound spectrum of *Nova Aurigae* might fairly be regarded as typical of temporary stars. This view had been confirmed by the observations of *Nova Carinae* in 1895, and of *Nova Sagittarii* and *Nova Aquilae* in 1898 and 1899, respectively; for these stars showed a similar spectrum. Nevertheless, many spectroscopists still adhered to an explanation based upon Doppler's principle. This was doubtless due to the fact that Wilsing's hypothesis offered an insufficient explanation of some of the most characteristic phenomena of temporary stars. Though presumably due to pressure, the shifts of the lines which he had measured in the spectrum of the spark in liquids did not seem altogether harmonious with the pressure shifts obtained by Humphreys and Mohler in gases, nor did Wilsing's assumption that pressures of several hundred atmospheres were involved seem consonant with the known physical conditions of the experiment. Finally, to omit mention of various minor objections, the dark lines in the spectra of temporary stars were known to be greatly displaced toward the violet, while the bright lines occupied nearly normal positions; whereas in the spark spectra recorded by Wilsing the dark lines were but little displaced, while the bright lines were considerably shifted toward the red.

It was with such questions as these in mind that the first experiments at the Yerkes Observatory were undertaken. Few results of importance, however, could be obtained with the induction

coils then available; and, in the absence of a suitable alternating dynamo, the discharge obtained in water was so unsatisfactory that the experiments had to be postponed. It fortunately became possible to renew them in the following summer, through the acquisition of a 1 K. W. Lakon transformer, giving 15,000 or 30,000 volts on open circuit, and the opportunity of using, through the kindness of Professor Crew, a 3. 3 K. W. alternating dynamo giving 110 volts.[1] With this apparatus, together with a large condenser and various accessories supplied through the kindness of Dr. George S. Isham and Mr. James Lyman, we were able to repeat Wilsing's experiments, and to extend them in various directions.

The possibility of varying the nature of the spectrum by altering the character of the high potential discharge was encountered early in our work, and has led us to undertake various investigations, some of which, if sufficiently developed, might ultimately possess considerable interest, especially from a physical or a chemical standpoint. In the course of these investigations it has been necessary to bear in mind the principal object of this research, viz., the bearing of the results on Wilsing's pressure theory of temporary stars. Nevertheless, we have thought it desirable to touch upon certain physical and chemical aspects of the problem, which, however, we have developed only far enough to suggest investigations which may prove to be worth undertaking in physical or chemical laboratories. The work on spark spectra in liquids comprises Part I of the present paper.

In attempting to form a clear conception of the phenomena of the high potential discharge in liquids, it was felt that an investigation should also be made of the spectrum of the high potential discharge in air and other gases at high pressures. The previous work of Humphreys and Mohler on the low potential discharge in air at pressures up to 14½ atmospheres had proved of great interest and importance from an astrophysical standpoint. This had led to the general adoption of a law of pressure-shifts, in which the change of wave-length is expressed as directly proportional to the total pressure of the surrounding air. It seemed probable that investigations made primarily for the purpose of elucidating the phenomena previously encountered in liquids might also render possible an extension of this law, or at least give a basis for the discussion of any differences in character which the low potential and the high potential discharges might exhibit. We hardly expected to find, however, that phenomena resembling those observed in liquids could be reproduced in gases at moderate pressures. Unfortunately, the removal of Dr. Kent from the Yerkes Observatory put a stop to this part of the investigation before it was fairly begun. An account of the few results obtained is nevertheless given in Part II of the present paper, as they are of some interest for comparison with the phenomena observed in liquids. No general discussion of these results is attempted, for lack of sufficient data.

Part III comprises a brief outline of the spectroscopic phenomena of temporary stars and some remarks on the bearing of our results on Wilsing's pressure theory. It is evident that the experiments we have been able to undertake are wholly insufficient, both in variety and extent, to provide a suitable foundation for a general discussion. We have therefore been compelled to limit ourselves to such considerations as are suggested by the work in hand, leaving a continuation of the discussion for some future occasion, when further data may be available.

The paper concludes with a summary of the results of our investigation.

[1] The apparatus was presented to Dr. George E. Hale for the use of the Spectroscopic Laboratory of the Yerkes Observatory.

I. THE SPECTRUM OF THE HIGH POTENTIAL DISCHARGE BETWEEN METALLIC ELECTRODES IN LIQUIDS

PREVIOUS INVESTIGATIONS

The possibility of producing compound spectra, consisting of pairs of bright and dark lines, by means of a high potential discharge in liquids, was first shown by Wilsing in 1899. He was led to undertake these experiments by the desire to extend the investigations of Humphreys and Mohler, whose work on the low potential discharge in compressed air covered the range from 1 to 14½ atmospheres. The work of Humphreys and Mohler had shown that the effect of pressure in an atmosphere of air surrounding an electric arc was to produce a displacement toward the red of the metallic lines given by the arc. Many of these lines were reversed, but special attention was called to the fact that the dark central lines of the reversals were displaced equally with the bright lines. It was also pointed out that the lines were but little widened by the effect of pressure.

As the lines were shifted at a pressure of 12 atmospheres by only about 0.05 tenth-meter, it appeared that in order to account for the relative displacements of the bright and dark lines in the spectrum of *Nova Aurigae*, amounting to from 10 to 20 tenth-meters, pressures of several hundred atmospheres might be needed. In order to avoid the experimental difficulties which the production of such high pressures might involve, Wilsing decided to investigate the spectra of high potential discharges in liquids, taking advantage of the pressure effect produced by the spark itself. Previous investigations along this line, beginning with the work of Masson, had not been quantitative in character, and seemed to have little or no bearing upon the questions at issue.[2]

The apparatus used by Wilsing in his experiments is described by him as follows:

> I employed in my experiments a large inductorium, in the secondary circuit of which a spark-gap was inserted before the electrodes in the usual way, in addition to the battery. With the passage of each spark a blinding discharge took place between the electrodes in the water, giving a very intense continuous spectrum crossed by faint lines. As the brightness of the continuous background and the flickering due to the irregularity of the discharge hindered the direct visual measurement of the lines, I photographed the discharge spectra in water and air on the same plate with a spectrograph, thus rendering possible a convenient and accurate determination of the relative position of the systems of lines of the two spectra. The length of the prismatic spectrum between λ4800 and λ4600 was about 50 mm., and the wave-lengths of sharp lines could be determined within a few hundredths of a tenth-meter. Besides this, Professor Lohse and Dr. Hartmann were kind enough to make me several plates with a grating spectrograph of high dispersion, and with a large prism spectrograph.[3]

In view of the results obtained in the present investigation, it is unfortunate that the spark apparatus employed by Wilsing was not more minutely described, as we now know that the exact conditions under which the discharge is produced have a most important bearing upon the spectroscopic phenomena obtained.

With this apparatus Wilsing investigated the spectrum of the spark in water between terminals of iron, nickel, platinum, copper, tin, zinc, cadmium, lead, and silver. In the spectrum of iron he found numerous pairs of lines in which the bright component was displaced considerably toward the red, while the dark lines were displaced by smaller amounts, in some cases toward the red and in others toward the violet. Certain isolated bright lines, unattended by dark companions, were similarly displaced toward the red. Reference is made to the fact that these lines are faint and ill-defined on the less refrangible edge. The displacements of a number of iron lines were measured by Wilsing; some of the results are given in Table I, where *e* denotes an emission line and *a* an absorption line. In the second column of Table I are appended, for comparison, values of the shifts of the same lines as given by our plate No. 666, which appears to have about the same degree of absorption as Wilsing's photograph.

[2] For an outline of the earlier work see WILSING, *Astrophysical Journal*, Vol. X (1899), p. 116.

[3] *Ibid.*, p. 118.

Wilsing points out that the apparent shift is greatest for bright lines which are accompanied by more refrangible absorption lines. This is due to the presence of two strata of vapor near the electrodes, "the inner and hotter of which gives broadened and displaced lines, while the outer and cooler gives a normal spectrum with narrow lines." Hence the violet side of the bright lines will be obscured by the absorption of the cooler vapor, leaving on the red side of the absorption line only the portion produced by broadening. For this reason Wilsing remarks that measurements of such bright lines cannot be depended upon to give a normal displacement. In other cases, depending upon certain variations in the intensity of the discharge and the development of vapors at the electrodes (which are not explained in the paper), the emission and absorption spectra change places, and may perhaps overlap each other in the integrated image.

TABLE I

SHIFTS AS MEASURED BY WILSING AND BY KENT

Degrees of absorption in the two plates approximately identical

Wave-lengths of Lines*	Displacements toward the Red in Tenth-Meters (Positive Unless Otherwise Stated)		Type of Line (e signifies emission, a signifies absorption)
	Wilsing	Plate 666 Kent	
3749.64	0.09	0.03	*a*
	.81	.54	*e*
65.70	.13	.10	*e*
67.32	.05	.01	*a*
	.17	.31	*e*
3815.99	−.07, −0.22	.01	*a*
	.51, 1.12	.45	*e*
27.98	−.10, −0.16, 0.00	.00	*a*
	.92, 1.06, 0.76	.37	*e*
34.38	−.07	.01	*a*
	.36	.38	*e*
4071.92	.11	.03	*a*
4118.72	.22	.03	*e*
4199.27	.16	.06	*e*
4307.96	−.05	−.01	*a*
	1.12	.44	*e*
83.71	.00	−.01	*a*
	1.33	.48	*e*

* Wave-lengths of lines and intensities taken from Exner and Haschek's tables of the spark spectrum of iron.

Various metals other than iron were also used by Wilsing. With platinum the lines were slightly diffuse, but no appreciable displacement could be detected. With nickel the lines were broader and more displaced than in the case of iron. Copper gave broad bands, which were even more characteristic of tin, zinc, and cadmium, where the displacements were very great. Some of these bands contain narrow maxima of intensity. While well-defined toward the violet, the bands were rather diffuse toward the red, though they usually had a more or less distinct boundary on this side, beyond which the intensity of the bright band fell off rapidly. In the zinc spectrum a prominent absorption line was found, considerably displaced toward the red. The strong cadmium line λ 4413.23 was not displaced, but merely symmetrically broadened. Silver gave no lines; a continuous spectrum only was present. Additional peculiarities were noticed in the case of magnesium, lead, and other metals.

In his further account of the results, Wilsing remarks:

The magnitude of the displacement and the broadening of the metallic lines is, indeed, of a similar order in the case of the various plates; yet considerable differences in the latter occur, which are in part to be attributed to the different duration of exposure and development of plates, but chiefly to the varying intensity of discharge, which changes with the strength of the current and the distance of the electrodes.

Wilsing suggested that it would be desirable to investigate the spectra in different liquids, and indeed tried both water and alcohol; but no appreciable differences were found in these two cases, and with oils the liquid was so rapidly clouded by decomposition that no photographs of the spectra could be obtained.

Wilsing remarks that his results are in agreement with those of Humphreys and Mohler, because in both investigations the lines in the spectra of tin, zinc, and cadmium suffered greater displacements than those in the spectra of iron and platinum. Assuming a proportionality between pressure and displacement, he concluded that the pressure resulting from the discharge in water must amount to several hundred atmospheres.

In commenting on these results, Kayser[4] states that he considers a quantitative comparison with the results of Humphreys and Mohler impossible. In this connection he points out that these investigators found the following displacements at a pressure of 12 atmospheres: Pt 0.02 tenth-meters, Fe 0.025, Cu 0.033, Sn 0.055, Zn 0.057; whereas Wilsing found: Pt 0.00, Fe up to 1.00, Cu up to 5.00, Sn up to 2.50, Zn up to 6.00.

In a paper read before the Royal Society on March 6, 1902[5] Lockyer describes his experiments at the South Kensington Observatory on spark spectra between metallic poles in water, and discusses their bearing on the results of Wilsing and the theory of temporary stars. In his earlier experiments the large Spottiswoode coil, capable of giving a 105 cm. spark in air, was used with a large glass plate condenser so that a spark 3 mm. long in air and about 0.5 mm. long in water was produced. Subsequently a 25 cm. coil was used in place of the larger one. With the latter coil, employed with a 45-liter Leyden jar, placed in parallel with the secondary circuit, photographs were made of the spark spectra of several metals in water, using a 15 cm. Rowland grating of 6.5 meters radius of curvature. Of the six metals examined only three—iron, zinc, and magnesium—showed reversals of the principal lines. In discussing his results Lockyer refers to the existence of several types of lines in the spectrum of a given element, and points out that in many cases the unsymmetrical reversals obtained closely resemble reversals which he had observed in the electric arc in air many years before. He divides the lines investigated into three types, as follows: (1) broadened bright lines, sharply defined toward the violet and diffuse toward the red; (2) broadened bright lines with central absorption; (3) broadened bright lines with non-symmetrical absorption, maximum of emission toward red.

Lockyer refers to variations in the relative intensities of certain lines, but he apparently did not recognize that the relative intensities, as well as the displacements of the lines and the absorption phenomena, can be varied between wide limits by such methods as will be described in the present paper.

In discussing the bearing of his results on Wilsing's theory of temporary stars, he concludes that "the pairs of bright and dark lines shown in the spectra of new stars do not arise from the cause which produces the appearances presented in the spectrum of the spark in water."

Konen's work[6] was devoted more particularly to the low potential discharge in liquids, but also contains important results obtained with the high potential discharge in water and other liquids. He distinguished between the results obtained with (1) the glow discharge; (2) the brush discharge; (3) the uncondensed spark; and (4) the condensed spark. He employed two induction coils, one giving a spark 30 cm. long, the other a very large coil made by Klingelfuss, giving a spark 1 m. long. This coil was supplied with currents up to 25 amperes developed by a storage battery. The primary current was made and broken by a Foucault interrupter, while the secondary spark could be condensed by the introduction of capacity to a length of 7 or 8 mm. in air, or 1 mm. in water. In

[4] *Handbuch der Spectroscopie*, Vol. I, p. 228.

[5] *Proceedings of the Royal Society*, Vol. LXX (1902), p. 31.

[6] H. KONEN, "Ein Beitrag zur Kenntniss spectroskopischer Methoden," *Annalen der Physik*, Vol. IV, No. 9 (1902), p. 742.

series with this spark was an adjustable air-gap. Electrodes of various diameters and shapes were employed, and the spectrum of the spark in a large number of liquids was photographed. No experiments were made on the effect of self-induction.

Konen's observations on the glow and brush discharges need not be referred to here, as they did not give the spectra of the electrodes, and such discharges were not employed in the course of our own investigation. With the condensed discharge short explosive sparks were obtained, which undoubtedly produced considerable pressure in the liquid. Konen found in all cases, as Wilsing had done, that the spectrum of the condensed spark contained both bright and dark lines. From this and other remarks in his paper it appears that he did not produce any important changes in the character of the spectra by changing the constants of the circuit. He was also unable to repeat our experiments, briefly described in a paper published in March, 1902,[7] which showed that the use of strong salt solutions will tend to increase the number and strength of reversals. Konen criticises Lockyer's contention that the phenomena observed are due simply to unsymmetrical reversal, and points out that Lockyer overlooked various types of lines. He also remarks that the displacements are very different for different lines, and considers that it would be useless to attempt an explanation of the phenomena given by the spark in liquids in the absence of more detailed investigations. From the table of wave-lengths and intensities which accompanies Konen's article, it would appear that his conditions corresponded closely with those which obtained in our own work when considerable self-induction was used in the discharge circuit. In the extreme ultra-violet, where the nature of our apparatus did not permit us to work, Konen found displacements of bright iron lines toward the red as great as 2 tenth-meters. In this region (λ 2606—λ 2755) the lines in his photographs were sharp. Konen also gives some results for aluminium and copper.

Three preliminary notes on our own experiments have been published. In the first of these[8] a brief account is given of our earlier results, showing that the reversal phenomena could be controlled by varying the electrical constants of the discharge circuit, and the nature of the liquid. In this paper it was stated that no dark lines were obtained in the spectrum of the discharge of an Apps induction coil. It was subsequently found that this result was due to the particular conditions under which the experiment was made, and that this coil will give results similar to those obtained by our transformers. It was also stated that the preliminary experiments to test the effect of self-induction had given negative results, but that they were regarded as inconclusive and would be repeated. With more suitable apparatus we have since found that the most satisfactory way of controlling the absorption phenomena is by varying the self-induction in the discharge circuit.

A second note[9] refers to the fact that in the spark spectra of a large number of metals the reversals first appear in the ultra-violet, and advance gradually toward the less refrangible region as the conditions for reversal become more favorable, thus corresponding with the results previously obtained by Liveing and Dewar with the electric arc. In a third note[10] we have given further results obtained with the spark in liquids, and a preliminary account of our more recent work on the spark in gases at high pressures.

APPARATUS

The apparatus employed during this investigation was as follows:

A. For producing the spark:

1. A 3.7 K. W. shunt-wound Weston motor, fed from the main 110-volt circuit of the Observatory power-house.

[7] [illegible]

[8] [illegible]

[9] [illegible]

[10] [illegible]

2. A 3.3 K. W. 8-pole alternator (amperes 30, volts 110), which gave, at 1,875 revolutions per minute (its normal speed), 125 complete cycles per second. As exciting current, the regular 110-volt circuit was used. In this circuit was placed a 50-step General Electric resistance box, which gave a maximum resistance of 75 ohms, or 1.5 ohms per step.

3. Three transformers:

a) A Lakon 1 K. W. instrument of four coils, two each in both primary and secondary, built for a primary potential difference of 110 or 220 volts (used by us always at 110), and giving a secondary terminal voltage of 15,000 or 30,000.

b) A "type H" General Electric 3.7 K. W. transformer, ratio of transformation 110 to 30,000. This instrument was kindly loaned to us by Professor Rogers, of Lewis Institute, Chicago.

c) An Apps induction coil, capable of giving a 12-inch spark from a primary current of 15 amperes. As used in this investigation the "make and break" was cut out, and an alternating current was passed through the primary.

4. To measure the current flowing, the potential difference at the transformer terminals, and the power developed, three Thomson instruments made by the General Electric Co.: (*a*) a watt meter reading to 25 hectowatts (potential limit 150 volts, current limit 25 amperes); (*b*) an ammeter, limit 50 amperes; (*c*) a volt meter, limit 150 volts. By use of a double-throw, double-pole switch the ammeter could be employed at any time to measure the current in the field circuit of the alternator.

5. A condenser built of 7.8 mm. glass plates and pieces of thin sheet brass, 30 cm. wide by 35 cm. long. Assuming the specific inductive capacity of glass to be 6, the capacity of a single elementary section would be probably about 0.0007 microfarads. The combinations generally used were:

4	plates	giving	about	0.003	microfarads
7	"	"	"	0.005	"
8	"	"	"	0.006	"
9	"	"	"	0.007	"
19	"	"	"	0.014	"

The maximum capacity obtainable was about 0.07 microfarads.

As considerable sparking occurred between the elementary sections, the condenser was covered with paraffin. Finally, as the difficulty was not entirely cured, part of the bank of plates, containing the sections of 1, 2, 4, 7, 8, 9, and 19 elements, was placed in a tank filled with transformer oil. This completely prevented sparking.

6. In the discharge circuit of the condenser, in series, *always*, (*a*) an air-gap, and (*b*) the vessel in which the discharge in the liquid occurred; also often (*c*) a coil of self-induction, (*d*) ohmic resistance, in the form of a column of liquid or a fine wire, or (*e*) a second or "accessory" spark-gap in a liquid or in air.

a) The air-gap terminals were mounted upon a rotatable device which held terminals of various shapes and sizes.

b) The first liquid receptacles were rude affairs. When the importance of the investigation had been fully proven, a more convenient vessel was built—a tank (made of 4 cm. oak) of which the internal dimensions were $17.5 \times 10 \times 10$ cm. This was fitted in front with a glass window, and on two sides with pieces of brass pierced with threaded holes through which were screwed brass rods. The inner ends of these were threaded, and to these ends were screwed small caps bearing terminals of the metals to be investigated. The caps could be removed by screwing the brass rods back a short distance. The spark-gap could be adjusted by screwing the rods in or out. An oaken cover was provided for use at higher liquid pressure.

This tank served for a time. Finally a more satisfactory vessel was made from a brass cylinder, 18 cm. deep by 10 cm. in diameter. The use of a metal made insulation necessary. Threaded brass

rods 15 cm. long entered the tank through ebonite cylinders, 3 cm. in diameter and 11 cm. long. The terminal-bearing caps were screwed on as before. Light from the spark reached the spectroscope through a glass window in the front of the tank, and a window in the rear permitted the spark to be seen while running. The tank was supported on an iron tripod, with leveling screws, by means of a hollow shaft, through which ran a drain-tube. A stop-cock at the end of the tube permitted a regulation of the flow of the liquid. A constant level was obtained by means of two efflux tubes set in the side of the tank, either one of which could be used. They gave water-levels of 15 mm. and 56 mm. respectively. The tank cover, which could be screwed on very quickly, was fitted with pressure gauges, influx tube, and a small check-valve to permit the air to escape while the tank was filling. Water was supplied from a pipe directly above the tank. The terminals of the water-gap were adjusted by inserting between them small pieces of brass (0.1, 0.2, 0.3, ... 1.0 mm. thick, as the case might be), and then screwing up the movable terminal until it touched the measuring piece lightly. Then the latter was withdrawn. During extended exposures the length of the gap was adjusted at regular intervals, which ranged in different cases from thirty seconds to five minutes, according to the rapidity of consumption of the metal. It was in this brass tank that most of the experiments described in this section were performed.

c) The self-induction coil was made of No. 16 B. & S. "okonite" covered, copper wire. The wire was wound on a cardboard cylinder in a single layer, and was split into sections of 2, 3, 4, 5, 6, 7, 8, 9, and 9 coils each, followed by nine sections of ten coils each, or 143 turns in all. The coil was 57.5 cm. long by 10.9 cm. in diameter.

d) Ohmic resistance was inserted in the form of either several yards of No. 23 B. & S. copper wire, or a column of liquid in a tube.

e) The accessory spark-gap was formed in various ways (see page 38, item 4).

At this point it may be well to state that in many cases, especially during the latter part of the investigation, the air-spark was rendered more regular and reliable by the use of an electric fan running at about forty revolutions per second. This permitted the use of combinations of the constants of the circuit which, without the fan, would have given intermittent water-sparks requiring very long exposures. So far as is known, the use of the fan makes no difference in the absorption phenomena. This statement is based on several separate experiments. Without the fan only the intermittent disruptive air-sparks cause a luminous discharge in the water; with it every discharge is disruptive. Thus the necessary exposure time is reduced.

B. For collecting the light of the luminous sources a simple and satisfactory arrangement was adopted. All pieces of apparatus were mounted rigidly on a circular table about 180 cm. in diameter, and were so placed that the sparks produced were situated on the circumference of a circle (139 cm. in diameter and eccentric with the table), on the center of which was a plane mirror capable of rotation about a vertical axis in the plane of its face. The light from any source could thus be thrown at once either (1) on a lens which focused it upon the slit of a low dispersion spectroscope—the arrangement used in the preliminary and qualitative investigation, or (2) upon a 22.5 cm. concave mirror (focal length about 2 meters), the position of which was such that an enlarged image was formed upon the slit of a concave grating spectroscope in an adjoining room—the arrangement used in quantitative work (Plate XVI).

C. For analyzing the luminous sources two sets of instruments were employed:

First, for the qualitative work, (*a*) the solar spectrograph formerly used at the Kenwood Observatory, equipped with a 30° reflecting prism; or (*b*) the one-prism stellar spectrograph, formerly attached to the 40-inch refractor.

Second, for the quantitative work, a 10 cm. Rowland concave grating, of 14,438 lines to the inch (5,672 to the cm.) and 3m. radius of curvature, giving a spectrum in the first order on the scale of 3.09 tenth-meters per mm. Only the first order was used. A difficulty was presented by the fact

that the ultra-violet and green regions of the spectrum were brilliant, while the violet was extremely weak. Therefore, to render uniform the extended region (28.7 cm.) covered in one exposure, from λ3380 to λ4990, a light cardboard screen, cut so as to expose the less brilliant portion for a greater time, was moved up and down during the exposure in a vertical plane 3 cm. in front of the plate. This motion was produced by a simple device run by a small electric motor. The arrangement worked so well that various screens were cut, suitable for both the comparison and the water spectra of the various metals.[11] It was found that the ordinary slotted metal shutter, turning about a horizontal axis, and used in photographing a comparison spectrum on either side of the water-spark spectrum, gave a decided diffraction effect at the junctions of the two spectra. To remedy this, the old shutter was replaced by two properly slotted metal shutters slipped in from above, one during the comparison spectrum exposure, the other during that of the water-spark. The advantage of this method lies in the fact that the latter form of shutter can be placed very near the plate (i. e., 11 mm.).

D. For measuring the displacements of the lines on the high dispersion plates a Zeiss comparator was employed, of double microscope pattern, giving a magnification of about eight diameters. A single wire was used in the eyepiece. The plates were placed violet left, and four settings were made upon the outer or comparison spectrum, and two upon the inner spectrum; then the same set of measurements was repeated with the plate placed violet right. Duplicate measurements of the same line generally agree to 0.01 tenth-meter. The measurements made upon the plates of the self-induction series are particularly reliable, owing to the fact that the self-induction renders the lines sharper. All of the measurements were made by Dr. Kent. The photographic plates used were Cramer "Isochromatic," and Seed "Gilt Edge" No. 27.

QUALITATIVE INVESTIGATION WITH LOW DISPERSION

General behavior of the spark in liquids.—A few general facts concerning the behavior of the spark in liquids are as follows:

A. In water:

1. Usually, when the water-gap is large (1 mm.), the discharges do not follow each other in rapid succession and are fairly disruptive. With a small water-gap (0.3 mm.) and moderate (5 mm.) air-gap, the discharge is more regular and more disruptive. With small water-gap (0.3 mm.) and large (20 mm.) air-gap, the discharge in water is very regular, and extremely brilliant and disruptive. In all these cases the accessory spark is supposed to be disruptive—inherently so, or rendered so by the action of the fan. When the accessory spark tends to arc, the spark in water either becomes intermittent or does not occur at all.

2. There may be produced a discharge which is fairly brilliant and regular, but so quiet that to hear it the ear must be placed quite near the tank. This discharge occurs when both air- and water-gaps are short (0.2 mm. and 0.5 mm.).

B. In liquids other than water:

1. The phenomena in general resemble those in water. In salt solutions of even as low as 1 or 2 per cent. concentration the spark becomes much fainter, more restricted in size, and often, in extreme cases, consists of merely a quiet, non-disruptive discharge of a reddish tinge. Strong (40 to 60 per cent.) zinc chloride solution produces the same effect; and the broad statement may be made that increasing the conductivity of the liquid produces a weakening of the spark.

2. In methyl alcohol the discharge is extremely brilliant.

3. In kerosene and glycerine a large amount of gas is evolved.

The previous statements refer to iron terminals.

[11] The intensity of the ultra-violet spectrum falls off rapidly after the spark is started, unless the water in the tank is frequently renewed.

Attention should be called to the fact that titanium and chromium in water give much more brilliant sparks than iron. This is especially true of titanium. The amount of vapor developed with both titanium and chromium is probably great because:

a) The spark is large in size.

b) The terminals are eaten away rapidly.

c) The shattering effect upon the terminals is very great.

These statements apply especially to titanium.

With strong (30 to 60 per cent.) zinc chloride and moderately strong (3 to 4 per cent.) sodium chloride solutions, the ends of the terminals become cup-shaped, suggesting that the discharge occurs principally between the central regions of the terminals. This phenomenon is not met with in the case of the spark in carbon dioxide and air at atmospheric pressure.

Results with iron electrodes.—When this investigation was first undertaken, it occurred to us that the character of the spectrum obtained might perhaps be altered by a change in the depth at which the spark took place beneath the surface of the water. Following out this idea, there was taken a series of six plates in which the water-level was varied from 25 cm. to 6 m. above the point of discharge. For a small water depth a wooden tank fitted with one glass side was used; for the greatest depths, there was substituted a glass bottle, provided with a wooden stopper, which was fitted with a tube by means of which the inclosed liquid could be subjected to the pressure of a column of water reaching to the level of the storage tanks of the building. For terminals, pieces of galvanized iron wire 2.3 mm. in diameter were used. The result was a rather remarkable set of plates, which showed a progressive change from a bright line spectrum at low water pressure to an absorption spectrum at the highest pressure. This change suggested further experiments in which capacity, length of water- and air-gap, diameter of water- and air-gap terminals, ohmic resistance, and self-induction in the discharge circuit were severally the variables. The investigation was made qualitatively, and the instruments used were the one prism solar and stellar spectrographs. The results are briefly described below. Table II shows the conditions under which the plates therein given were taken.[12] The conclusions are based, not merely upon these typical plates, but upon a large number of exposures made at various times throughout the investigation. In view of the complexity of the phenomena, and the extreme difficulty of controlling all the conditions that may affect them, some of these conclusions are to be considered as merely probable, rather than as absolutely proved. The original purpose of the investigation (i. e., the bearing of spark spectra in liquids on the theory of temporary stars), and the time at our disposal, did not seem to warrant a complete study of all the phenomena encountered.

1. Change in length of water-gap (Plate 151). A 0.2 mm. gap gives a spectrum marked by strong absorption, while a 1.0 mm. gap gives one of medium absorption. (The use of a very large gap, over 1.0 mm. for instance, will often cause all lines, both bright and dark, to disappear, and will give only a continuous spectrum.) *Increase of water-gap decreases the absorption.*

2. Change in length of air-gap (Plate 265). There is a marked change from moderate to strong absorption in passing over the range, 1, 10, 20 mm. *Increase of air-gap increases the absorption.*

3. Insertion, or change in length, of second water-gap (in series with first water-gap; Plate 831). A small change toward less absorption appears when the second gap is enlarged from 0.1 to 0.8 mm. (the same tap water is used in the second tank and the discharge is luminous). For the effect when other liquids are used, see pp. 43, 44, 45. *The introduction, or increase in the length, of a second water-gap decreases the absorption.*

4. Change in length of second air-gap (Plates 370, 385, 393). (*a*) When the first air-gap is small (e. g., 5 mm.)—an increase in the second from 0 to 24 mm. produces a large increase in absorption. (*b*) When the first is large (e. g., 19 mm.)—a moderate increase—e. g., from 0 to 6 mm.—

in the second produces but a small change. A train of nine equal gaps (formed by pieces of galvanized iron wire, 2.3 mm. in diameter, bent and fastened to a board), giving a total gap of 14 mm. increases the absorption somewhat; and a train of nine, of a total of 36 mm., in combination with a capacity of 0.03 microfarads, a water-gap of 0.1 mm., an air-gap of 19 mm., and no resistance in the transformer circuit, produced the highest absorption obtained by us on any water-spark plate. Very few (only nine) bright lines are shown, and the absorption extends far toward the red; λ4891.62 is absent; λ4920.63 and λ4924.00 are bright lines; and λ4957.80 is reversed. On all our other water plates this last line has appeared bright, although often much shattered and broadened. In general, then, an *increase of the second air-gap, or an introduction of many gaps of moderate length, increases the absorption.*

5. Change in diameter of water-gap terminals. In the preliminary qualitative investigation no plates were taken with the distinct object of showing the effect of change in this constant. Such were taken somewhat later with the large grating, and it was found that an *increase in the diameter of the water-gap terminals increases the absorption.*

6. Change in diameter of air-gap terminals (Plates 824, 825). The terminals used were rounded so that surfaces which were approximately spherical and of diameters 4 mm. (in Plate 824) and 1.5 mm. (in Plate 825) were presented to each other. The resultant difference is small, but unmistakable. With flat ends no difference is apparent. This may be because the discharge in both cases passes between edges. *Increase of diameter of air-spark terminals increases the absorption.*

7. Change of capacity (Plates 286, 289). Many sets of plates were taken at different times, and under various conditions. The effect is evident, but usually small, owing perhaps to the limited range of capacity at our disposal (0.003 to 0.07 microfarads). *Increase of capacity increases the absorption.*

8. Change in temperature of the liquid (two sets of plates, 799 to 801 and 806 to 808). In the first set no particular care was taken to have the kind of water used in the three cases precisely the same. In the second set water was cooled by immersing ice in it; small pieces were left in the spark tank during exposure; and then the same water was filtered through cotton and heated to higher temperatures. The liquid used was thus practically the same throughout the set. The temperatures employed in this second case were 174°, 72°, and 45° F. *Both sets agree in giving a small increase of absorption with decreasing temperature.*

9. Change of self-induction in the discharge circuit (Plates 644, 646). The spark under water is in all cases extremely sensitive to self-induction. Even two or three turns of the self-induction coil previously described will, under certain conditions, produce a change in the absorption, and the whole coil of 143 turns changes a high-absorption spectrum almost completely to a bright-line spectrum (in the violet and ultra-violet). *Increase of self-induction in the discharge circuit decreases the absorption.*

10. Change of ohmic resistance in the discharge circuit (Plates 283, 284). The insertion, non-inductively, of 57 feet of No. 23 B. & S. copper wire produced a spectrum marked by less absorption than that obtained without such ohmic resistance. *Insertion of non-inductive resistance decreases the absorption.*

11. Change of resistance in field circuit of alternator (Plates 464, 466). By moving the arm of the field rheostat it was apparent that there was a point at which the spark was both more brilliant and more disruptive. At this point the circuit acted as though it were in resonance. Two exposures were made on each of the two plates, on 464 at resistances 0 and 39 ohms—"resonance" at 39; and on 466 at 34.5 and 56.5 ohms—"resonance" in this case being at the point of less resistance, namely, 34.5 ohms. In both cases distinctly greater absorption is shown at "resonance," and the watt meter there registers greater energy. *Therefore the absorption is increased by an approach to a condition of "resonance," whether this process involves an increase or decrease in field circuit resistance.*

12. Change of resistance in primary circuit of transformer (Plate 262). *A decrease of resistance in the primary circuit of the transformer produces increased absorption.*

13. Change of transformer (Plate 828). On the plate cited the Apps induction coil spectrum is marked by more absorption than that given by the Lakon transformer connected for 15,000 volts. It cannot be definitely stated that this will always be the case. Under the conditions used in obtaining Plate 828 the induction coil produced a more regular, brilliant, and disruptive spark.

In the first published note regarding the results obtained with the spark in liquids it was stated that a bright line spectrum, with no reversals, was obtained with the iron spark in water when the Apps coil was used. This was indeed the case. But the constants of the circuit, Plate 227, were such as would have properly produced an emission spectrum even if the Lakon transformer had been used. The diameter of the water-gap terminals was small (1 mm.), the capacity was 0.006 microfarads, the water level was 26 mm., the fan was not running, and the water-spark was short; the air-spark was rather long, but its terminals were small, and the spark was weak.

From paragraphs 11, 12, and 13 it may be seen that the phenomenon under discussion is probably not merely a function of the electric constants of the circuit on the discharge side of the condenser (the degree of absorption being determined only by these and the capacity), but depends also upon the transformer used and the current flowing in the external and field circuits of the alternator. It may be that other electrical constants of the circuit, as yet unknown, also have an influence upon the character of the spectrum obtained.

14. After several sets of experiments dealing with the problems just presented had been made, it appeared desirable to repeat the original water-pressure series, using the improved apparatus, the brass tank previously described. We were surprised to find that the water-pressure effect could generally be obtained to only a small degree, and under some conditions did not appear to exist at all. It was only after many attempts, made at different times throughout the investigation, that the conditions which are conducive to a distinct change were discovered.

We can make no very positive statements regarding the water-pressure effect, but it will probably appear whenever the constants of the circuit are such that (1) at low water pressure the air-spark burns rather quietly (but with sufficient disruption, of course, to cause a luminous discharge across the water gap), and is characterized by a red or pink color; and (2) at high pressure the reaction of the water-spark will be such that the air-spark burns very disruptively and possesses a violet color. In obtaining such a state of the circuit, the following considerations are of value:

1. The water-gap should be short, from 0.1 to 0.3 mm. The diameter of the water-gap terminals ordinarily used was 2.3 mm. (no study of the bearing of a change of this constant upon the pressure effect was made).

2. The air-gap should be short, 0.5 to 1.0 mm.; and the diameter of the terminals small, e. g., 0.8 mm.

3. A certain small amount of self-induction in the discharge circuit (e. g., 2 turns of the coil) is favorable, but not essential. Similarly, a small amount of ohmic resistance is advantageous.

4. The capacity must be large enough (e. g., 0.005 to 0.007 microfarads) to cause sufficient disruption over the air-gap to produce a luminous discharge in water.

In this connection it may be stated that the use of the fan upon the air-gap is not prohibitive of the effect.

5. The conditions of the air of the room possibly have an effect. In a cool, dry atmosphere the air-spark seems to burn quite disruptively; in a warm, moist atmosphere, quietly; and, although all the electrical constants of the circuit may be identical and the water-level be the same, the spectra may differ considerably. The dry air tends to produce an absorption spectrum; the moist air, a spectrum marked by more bright lines.

The conditions under which the original set of plates were taken chanced to be quite similar to those given above. It is rather odd that this water-pressure effect which, of all the phenomena investigated, proved the most difficult to reproduce, should have been encountered first.

The above data suggest that an increase of water pressure produces increased absorption in the spectrum primarily by altering the electrical conditions of the circuit, rather than by changing the physical condition of the water-spark, by creating a greater amount of absorbing vapor, or massing it more closely around the spark. To settle this question, the following experiment was performed. Two tanks, the brass and the wooden, were placed in series, and the circuit arranged for as low absorption as possible consistent with good running. The conditions were as given in Table II, Plates 796 98 and 809–13. A complete set of plates is schematically as follows:

PLATE A, EXPOSED TO SPARK IN BRASS TANK

Exposure No. 1: Level of water in brass tank 15 mm.; in wooden tank 15 mm.
Exposure No. 2: Level of water in brass tank 6 m.; in wooden tank 15 mm.

PLATE B, EXPOSED TO SPARK IN WOODEN TANK

Exposure No. 1: Level in brass tank 15 mm.; in wooden tank 15 mm.
Exposure No. 2: Level in brass tank 6 m.; in wooden tank 15 mm.

In both A and B greater absorption is shown when the spark in the brass tank is subjected to the pressure of 6 m. of water. The experiment was repeated several times under slightly different conditions. In all the spectra taken from the oak tank spark there appears a difference in the direction: greater pressure more absorption; while the difference in the brass tank spectrum is not always noticeable, but, when apparent, it is in the same direction. The experiment is difficult to perform because of the many and delicate adjustments to be made.

This seems to indicate that the effect, if genuine, is electrical, for increased pressure in the brass tank produces increased absorption in the wooden tank.

Results with electrodes of metals other than iron.—To discover whether or not this progressive absorption, following suitable changes of electrical conditions, was a general phenomenon and not one peculiar to iron alone, a series of plates was taken with other metals: for every metal one or more plates containing in most cases two exposures, one given under low absorption conditions and another under high.

Manganese, antimony, bismuth, tin, gold, calcium, silver, nickel, cobalt, and titanium follow the rule given for iron, and their spectra present no marked peculiarities.

Aluminium, besides following the general rule, presents the interesting phenomenon of double reversal. Three exposures, under conditions such that a progressive change of absorption should appear, were made upon one plate (No. 445). In all three spectra the two chief aluminium lines, $\lambda 3944$ and $\lambda 3962$, appear as broad absorption lines. In the lowest absorption spectrum these two lines have at their extremities faint but fine bright lines. In the medium absorption spectrum these bright lines are very intense, and extend over the whole length of the absorption line; in the spectrum taken under the highest absorption conditions, they are absent entirely. Similar dark and bright lines are present in the iron spectrum, but the problem of their behavior has not been studied fully enough to warrant any statement concerning them.

Lead ($\lambda 4058$) and cadmium ($\lambda 3611$) show changes which, as far as investigated, are similar to those of iron.

Magnesium shows the flutings betweeen $\lambda 5100$ and $\lambda 5200$ (Plate 352); and it is in them that the progressive absorption is most clearly apparent. Under high absorption conditions they appear composed of clearly marked dark lines. On the other hand, $\lambda\lambda 3830$, 3832, and 3838 remain very sharp bright lines throughout the series of exposures.

TABLE II

LOW DISPERSION OR QUALITATIVE PLATES). PHYSICAL AND ELECTRICAL CONDITIONS DURING EXPOSURES

Plate No.	Distance of Slit from Arc in mm.				Metal and Shape				Field Current in Resistance in Ohms*	Degree of Resistance in Ohms*	Capacity in Microfarads	Self Induction in Henrys	Date Received	Water Level in cm.	Transforming Load	Remarks
	Water	Air	Second Water	Second Air	Water*	Air	Second Water	Second Air								
1	6.2	1.0			*Fe* Wire	Bessem'r Steel			0	4	0.0058	0	No	26	Lakon 30,000	
2		0.1			Bessem'r Steel	"			0		0.0058	0	"	26	Apps	
3									10	4.0	0.0058	0	"	26	Lakon 15,000	
4		1.10.20							0	4	0.0058	0	"	26	"	
5									0	4	0.0058	0	"	26	"	In 283 no resistance in discharge circuit.
6									0	4	0.0058	0	"	26	"	In 284 57 feet of No. 24 copper wire in discharge circuit.
7									0	4	0.0058 0.0597	0	"	26	"	
8		1.0			*Mg*				22	4	0.0058	0	"	26	"	
9			3.6		Bessemer Steel	"		Bess. St.	0	4	0.0058	0	"	26	"	14 mm. gap, formed of train of 9 gaps of 1 to 3 mm. each
10			14					*Fe* Wire	0	4	0.0058					
11		1.1	36					"	0	6	0.6280					36 mm. gaps formed of 9 gaps.
12									45	6	0.0014					
13					*Al*	Brass			37	4	0.0058	0	"	26	"	
14		1.0							0	2	0.0182					
15		1.0			Bessemer Steel	"			0.39	4	0.0058	0	"	26		"Resonance" at 26.
16		1.0				"			56.5.34.5	4	0.0029					" " 23.
17		1.0			"	Bessem'r Steel‡			0	4	0.0066	143 0	"	56*	Lakon 30,000	
18	0.1	1	0.1		*Fe* Wire	*Fe* Wire	Bessem'r Steel		0	4	0.0014	0	Yes	15		A second exposure made at 8.5 lbs. pressure
19	0.1	1	0.1						0	4			"	15	"	" " " " 10 " "
20	0.1	1	0.1						0	4			"	15		" " " " 10 " "
21	0.1	1.0			"	Brass			0	4	0.0014		No	15		Water at 140 F.
22																" " 76
23																" " 46
24												0				" " 45
25	0.1	0.5				Bessem'r Steel‡			0	4	0.0014		"	15		" " 72
26																" " 174
27	0.1	1.0	0.1		Bessem'r Steel	*Fe* Wire	Bessem'r Steel		0			0	No			Exposures made on brass and oak tanks as described on p. 41.
28	0.1	1.0	0.1						0			0	"			
29	0.1	1.0	0.1						0	4	0.0051	2	Yes	15	"	
30	0.1	1.0	0.1						0			345	"			
31	0.1	1.0	0.1						0				"			
32	0.3	2			"	"			0	4	0.0066	0	"	15	Lakon 15,000	
33	0.3	0				"			0	6	0.0066	0	"	15	Apps Lakon 15,000	
34	0.3	3	0.1 0.8		"	"	Bessem'r Steel		0	6	0.0066	0	"	15	Lakon 15,000	

* Has core always used. † Over and above resistance of field coils of alternator and primary winding of transformer respectively. ‡ Rounded end.

§ The low dispersion plates from Nos. 1 to 553 (inclusive) were taken with the solar spectrograph, and those from Nos. 554 to 881 (inclusive) were taken with the stellar spectrograph.

Results with liquids other than water.—

1. At the beginning of this investigation the question was raised whether or not the character of the iron spectrum might depend upon the nature of the liquid in which the discharge took place. Moreover, it appeared probable that the electrical conductivity might enter as a determining factor. Naturally, therefore, non-conducting liquids, salts of different conductivities, and various concentrations of the same salt were tried.

2. Three sets of plates were taken, the members of each set being comparable among themselves. The results may be summarized in the following tables, in which the conductivity is calculated (by reference to Landolt and Börnstein's tables[13]) from either the known concentration or the measured resistance.[14] The liquids are arranged in groups in order of decreasing absorption—e. g., in Table III, group "a_1" shows the greatest absorption, and group "d_1" the least. The groups of the three tables are not related.

TABLE III*

CONSTANTS: $G=0.3$; $g=19$; $D=2.3$; $d=4$; $c=0.006$; $h=26$

Liquid	Concentration	Conductivity	Group
Gasoline	....	0	
Glycerine	....	0	a_1
Benzine	....	0	
NaOH	0.8 %	$3{,}300.\times10^{-9}$	b_1
KOH	1.2	$3{,}300.\times10^{-9}$	c_1
Distilled water	....	$10\ \times10^{-9}$	d_1

*The abbreviations at the head of each table have the following significance:
G stands for length of primary gap in millimeters.
g " " " " secondary " " "
D " " diameter of primary terminals in millimeters.
d " " " " secondary " " "
c " " capacity in microfarads.
h " " distance from terminals to surface of liquid in millimeters.

TABLE IV

CONSTANTS: $G=0.2$; $g=10$; $D=2.3$; $d=4$; $c=0.006$; $h=26$

Liquid	Concentration	Conductivity	Group
Methyl alcohol	....	0	a_2
Kerosene	....	0	b_2
BaCl	19%	$11{,}900.\times10^{-9}$	c_2
NaCl	1	$1{,}380.\times10^{-9}$	d_2
NH_4OH	3	900×10^{-9}	e_2
NH_4OH	25	1×10^{-9}*	f_2
NH_4OH	50	?	g_2
Tap water	....	?	h_2

*Extrapolated from data given by Landolt and Börnstein.

TABLE V

(For constants of the circuit see below, paragraph 5)

Liquid	Concentration	Conductivity	Group
NaCl	8%	9300×10^{-9}	a_3
NaCl	4	5270×10^{-9}	b_3
NaCl	1	1360×10^{-9}	c_3
NaCl	$\frac{1}{8}$	186×10^{-9}	d_3

[13] In Landolt and Börnstein's tables the conductivity of a column of mercury of specific dimensions is taken as unity.

[14] Determined by Kohlrausch's alternating current method.

3. At this point it may be well to note that our first plates taken with glycerine showed a bright-line spectrum devoid of all absorption lines, whereas other non-conducting liquids, such as gasoline and benzine, produced a spectrum marked by high absorption. It had been noticed, however, that with this viscous liquid the bubbles of gas formed by the discharge were both large and slow in rising from the terminals; and it seemed probable that after the first spark the discharge took place in the gas. This would explain the bright-line spectrum. To avoid this difficulty, the switch in the primary circuit of the transformer was closed for as short a time as possible, and the bubbles allowed to rise out of the way between each set of sparks. The result was a spectrum marked by as high absorption as those given by gasoline or benzine.

From the data given in these three tables (III, IV, and V), it is clear that the electrical conductivity is not the sole determining factor. The character of the liquid has an influence.

4. To study the electrical effect upon the circuit and differentiate it from any other possible effect, the accessory tank, which we shall call T_1 (that used in connection with the hydrostatic pressure effect in the case of pure water; see p. 38.), was joined in series with the original tank, T_0, and the air-gap. Various liquids were placed in T_1, and their effect upon the spectrum given by the ordinary arrangement (iron terminals and tap water) in T_0 was studied.

Here a distinction must be made between two sets of phenomena in T_1. In the first the discharge passes disruptively, and a spark results; while in the second the current is conducted without disruption and no sparks appear.

5. *First*, a disruptive discharge in T_1. The order is:

1 per cent. NaCl solution, showing greatest absorption in T_1
0.5 per cent. NaCl solution, showing less absorption in T_1
Tap water, showing least absorption in T_0

The constants of the circuit here were $G=0.2$; $G'=0.2$; $g=14$; $c=0.012$, where G' stands for the length (in mm.) of the spark-gap in the accessory tank. Moreover, an increase of the gap in this accessory tank tends to produce a bright line spectrum in T_0. But when glycerine, gasoline, or "18 to 1" transformer oil[5] are used in T_1, an increase in G' increases the absorption in T_0; and even when G' is small, the absorption is a little greater than when no accessory tank is introduced into the circuit. In this respect the introduction of this accessory tank resembles in its effect that of a second air-gap (the influence of which has been discussed on p. 38).

Again, *second*, a non-disruptive discharge in T_1:

A 4 per cent. solution of NaCl gave a spectrum marked by far greater absorption than did tap water. The constants of the circuit were: $G=0.2$; $G'=10$; $g=19$; $c=0.006$.

Moreover a 10 per cent. solution of NaCl produced a spectrum which showed much less absorption than that given where a thick wire replaced the tank T_1. The constants of the circuit were: $G=0.2$; $G'=22.5$; $g=19$; $c=0.006$.

The order is:

a) Thick wire (no accessory tank), greatest absorption in T_0
b) 4 per cent. to 10 per cent. NaCl solutions in T_1, less absorption in T_0
c) Tap water in T_1, least absorption in T_0

Therefore the introduction of a salt solution (or tap water) in this manner gives results similar to those obtained by introducing ohmic resistance or self-induction in the discharge circuit, and the longer the gap G', the greater the tendency toward a bright-line spectrum.

The conclusions to be drawn from the data here given are:

That the influence of the liquid in the tank T_1 upon the spectrum given in T_0 cannot be chemical—it must be electrical.

b) That in the case of a conducting liquid like a NaCl solution, whether the spark be passing or not, an increase in the conductivity of the liquid in T_1 produces an increase in absorption in the spectrum of T_0. The effect thus corresponds with the reduction of ohmic resistance in a metallic circuit (p. 39).

c) That the introduction of a non-conducting liquid in T_1 tends to increase the absorption in T_0, and an increase of G' produces an increase in absorption in T_0. (See the effect of increasing an auxiliary air gap, p. 39.)

6. Again, to eliminate the electrical effect, a series of plates was taken in the following manner: Tank T_0 was filled with tap water and T_1 with a 1 per cent. salt solution. The constants were. $G=0.2$; $G'=0.2$; $g=10$; $c=0.006$, which arrangement gave a spark in both tanks. The depth of each liquid was 26 mm. The spectrum given by tank T_0 was photographed; then the central mirror was turned, and upon the same plate was placed the spectrum of T_1. To confirm the results this plate was duplicated. Then the liquids were interchanged, T_1 being filled with tap water and T_0 with the 1 per cent. salt solution—this to eliminate the possibility of an effect due to a possible difference of some nature in the tanks. Exposures of both sparks were made as in the first series, and in this case three identical plates were taken. In all five plates the NaCl solution gives the spectrum marked by the greatest absorption. From this we must conclude that the influence of the salt solution must enter in determining the absorption in at least one other way than that of changing the electrical constants of the circuit, for the two exposures on any one plate were taken under the same electrical conditions. We are forced to believe that there is a chemical effect, created by the salt solution upon the iron.

7. Again, to separate the effect of quantity of salt or concentration from that of conductivity, it was desirable to obtain a liquid which has the same conductivity at two different concentrations. Zinc chloride fulfilled this requirement. Its conductivity-concentration curve reaches a maximum at approximately 30 per cent., and the conductivities of a 4 per cent. and 58 per cent. solution are almost identical. The more concentrated solutions were somewhat viscous and presented the same difficulty as glycerine. But the single-spark method of exposure removed the difficulty.

Starting with a 58 per cent. solution two series of plates were taken, each series representing spectra given at four points on the curve. Each exposure was made in duplicate. Both sets gave the same results, and exposures made under similar conditions agreed satisfactorily. The results may best be shown by the study of a set of nine lines which are most susceptible of change under the conditions employed.

The constants were: $G=0.3$ for series No. 1 and 0.4 for series No. 2; $g=19$; $D=1$; $d=4$; $c=0.012$. The accompanying table (VI) explains itself.

After dilution at point No. 2 on the curve (see Fig. 1), the solution gradually clouded with a white precipitate, and the concentration changed, passing around the curve. After a short time the solution was filtered, and exposure made at point No. 3. The concentration was calculated from the measured resistance by use of Landolt and Börnstein's tables, and also (until precipitation) from the known dilution.

The natural conclusion is that the amount of the salt present has a marked influence apart from the conductivity. In fact, from the different rates of change—slow between points No. 1 and No. 2, and rapid between No. 2 and No. 3, and between No. 3 and No. 4—and by reference to the conclusions drawn in paragraph 5, the following deductions are rendered probable:

a) That an increase in the quantity of the salt present tends to increase the absorption chemically; and

b) That an increase in the conductivity of the solution tends to increase the absorption electrically. These two tendencies are in opposition on the first third of the curve, the second is approximately eliminated in the second part, and they act together in the third.

TABLE VI

ZINC CHLORIDE SOLUTION. ABSORPTION AS A FUNCTION OF CONDUCTIVITY AND CONCENTRATION

Photograph or Curve	No. of Lines Appearing as Full Absorption Lines	No. of Lines Appearing as Bright Edges	No. of Lines Appearing as Bright Lines	Resistance* of Solution in Ohms	Conductivity† 10^6	Percentage Concentration of Solution
FIRST SERIES. LIQUID GAP = 0.3 MM						
1	5‡	3‡	1	8.30	4032	58
2	0	8	1	4.55	7400	45
3	0	5	4	4.65	7200	12
4	0	3	6	8.30	4032	4
SECOND SERIES: LIQUID GAP = 0.4 MM.						
1	0‡	8‡	1	8.30	4032	58
2	0	8	1	4.55	7400	45
3	0	5	4	4.65	7200	12
4	0	3	6	8.30	4032	4

*Measured by Kohlrausch's method.

†As given by Landolt and Börnstein. Standard chosen is mercury.

‡It will be noticed that the length of liquid gap was 0.4 mm. in the second series and 0.3 in the first. This perhaps explains the presence of five full absorption lines and three absorption lines with bright edges in the first set, while no full absorption lines, but eight with bright edges, appear in the second. At highest concentration the length of gap appears to be particularly influential in producing a change in absorption.

8. The general conclusions which seem to follow from the data given in the seven preceding paragraphs are as follows:

a) That non-conducting liquids (like an auxiliary air gap) increase the absorption of the spectrum given by the terminals immersed in them principally, if not entirely, by reason of their influence upon the conditions of the electric circuit.

b) That conducting liquids increase the absorption somewhat by means of their electrical influence, but mainly by the chemical action upon the terminals. This conclusion is in harmony with the results of Bredig and Haber, who have found that in high potential electrolysis, and with metal arcs and sparks under water, the presence of alkali causes more rapid pulverization of the electrodes.[16]

To illustrate the changes in the spark between iron electrodes in water under different electrical conditions, and in sodium chloride solutions of different concentrations, enlargements of plates obtained at low dispersion were made and arranged in order of increasing absorption. Plate XVII[17] represents the result. All the changes apparent relate to the iron lines of the spark, and not to lines due to substances present in the particular liquid employed. It should be stated that as subsequent experiments never showed such marked increase of absorption as these salt solutions seemed to produce, other causes, unknown to us, may have enhanced the effect in these photographs.

No great weight can be ascribed to the conclusions of this section of our paper. The importance of this work did not seem sufficient to warrant the expenditure of the time required to clear up all doubtful points.

QUALITATIVE INVESTIGATION WITH HIGH DISPERSION

The preceding results were obtained with spectroscopes of low dispersion, capable of showing the general character of the absorption phenomena in a satisfactory manner, but not adapted for a precise study of the shifts of the lines under different conditions, or of the details of the absorption phenomena. This work was accordingly undertaken with the concave grating spectroscope described

on page 36. A 15 cm. grating of 6.5 m. radius was employed for various special studies, but the greater part of the work was done in the first-order spectrum with a 10 cm. grating of 3 m. radius. Suitable shutters made possible the method of double exposure of the comparison spectrum. Generally a spark in air was exposed first and placed upon the outer portions of the photographic plate; then the spectrum of the spark in the liquid was thrown upon the center of the plate; and finally, in the third exposure, a spark in air was superposed upon the first.[18]

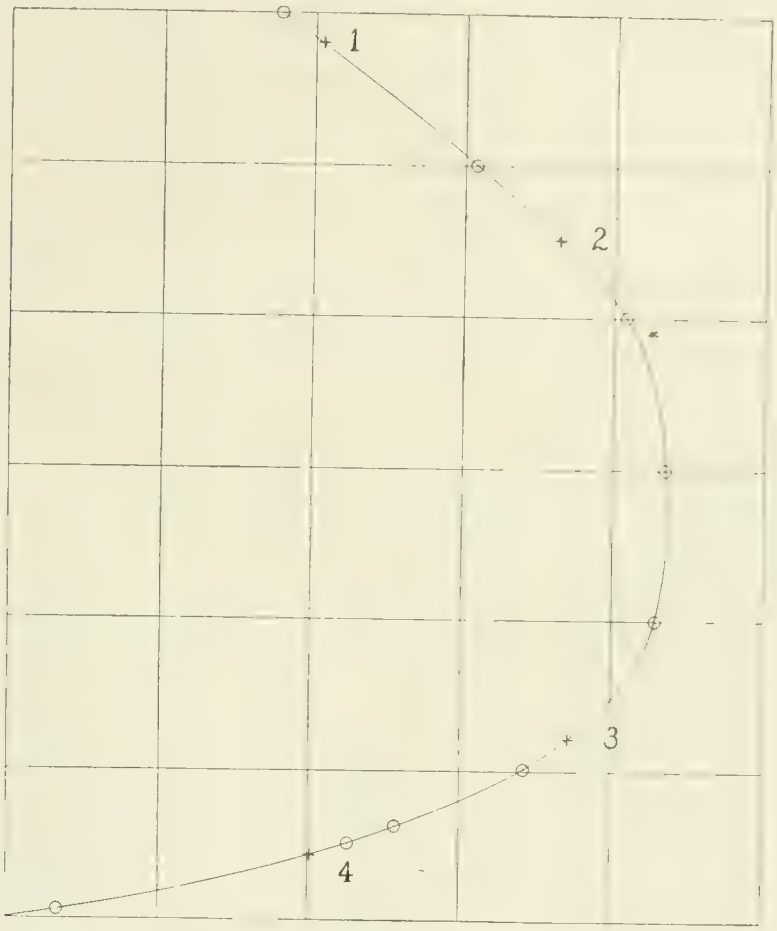


FIG. 1

Percentage Concentration	Conductivity (compared with Mercury)
0.64	780×10^{-9}
5.00	4520
6.35	5178
10.00	6800
20.00	8530
30.00	8660
40.00	7900
50.00	5890
60.00	3450

[18] In all cases the constants of the electrical circuit used to give the comparison spectrum were as follows:

Length of spark, 4 mm.; size of Bessemer steel terminals, 2×5 mm.; no field resistance (other than that in the field coils themselves); field current, about 4.5 amperes; transformer resistance, 4 ohms when the General Electric transformer was used, and 3 ohms with the Lakon transformer; power, 90 watts; current, 23 amperes; potential at primary terminals of transformer, 3 volts; and capacity, 0.014 microfarads.

In discussing the results obtained on the high dispersion plates, we may consider them in the following order:

A. Details of absorption phenomena and types of lines represented on the plates.
B. Absorption phenomena produced by changing the constants of the circuit.
C. Shifts of the lines produced by changing the constants of the circuit.
D. Shifts of the lines in a solution of sodium chloride.
E. Spectrum of the rotating arc in liquids.

A. *Types of Lines.*—Reference has already been made to the various types of lines distinguished by Wilsing, Lockyer, and Konen. On our high-dispersion photographs ten distinct types occur in the spectrum of iron as follows:

(1) Narrow emission line.
(2) Broad, fairly symmetrical, emission line.
(3) Broad emission line, diffuse toward the red.
(4) Simple absorption line.
(5) Absorption line superposed fairly symmetrically on broad emission line.
(6) Absorption line superposed on broad emission line, which is strongest on red side.
(7) Similar to (6), but with the violet component of the emission line lacking.
(8) Narrow emission line, superposed symmetrically on absorption line; a combination of (1) and (4).
(9) Absorption line, with narrow emission line through its center, superposed fairly symmetrically on broad emission line: a combination of (1) and (5).
(10) Absorption line, with narrow emission line through its center, superposed on broad emission line, which is strongest on red side: a combination of (1) and (6).

These several types are illustrated in Plate XVIII. In studying the shifts of the lines under various conditions, it is of importance that the corresponding type should be recorded in each case.

It is, however, difficult to classify lines of types (5), (6), and (7), because the difference between (5) and (6), and between (6) and (7) is so slight. Prolonged exposure may bring out a violet component of the line which at normal exposure appeared to be of type (7). The differences between the three types depend upon (*a*) the width of the basal emission line, (*b*) the width of the absorption lines, and (*c*) the relative positions of the maxima of emission and absorption. From the data at hand it is impossible to divide these lines into three classes with absolute precision. The shifts of the emission components of the lines of types (5), (6), and (7) were measured only in the case of type (7). With compound lines, particularly those of types (6) and (7), as both Wilsing and Lockyer have pointed out, a setting on the middle of the displaced bright line does not give the true displacement, on account of the presence of the absorption line. Again, it is important to ascertain, in studying the displacement of the bright lines, whether we are dealing with a case of unsymmetrical widening toward the red, where, as Kayser[19] has so conclusively shown, there may be no real shift of the line, or whether there is a true displacement of the line as a whole.

It should perhaps be noted that lines of types (8), (9), and (10) cannot be explained on the assumption of a [illegible] double exposure of the plate, producing a superposition of the comparison spectrum of the spark in air upon the spectrum of the water-spark. For the negatives which show lines of these types also have upon them strong lines of types (5) and (6), in which any chance superposition would be at once betrayed. We seem to be dealing here with true double reversals. The interest in these lines is increased by the fact, which Kayser has pointed out, that true cases of double reversal are difficult to produce at will by ordinary laboratory methods. In the present case there is no difficulty in obtaining such lines as often as may be desired.

TABLE VII

HIGH DISPERSION OR QUANTITATIVE PLATES: PHYSICAL AND ELECTRICAL CONDITIONS DURING EXPOSURES

No. of Plate	Length of Gaps in cm.		Diameter of Terminals in cm.		Metal and Shape		Field Circuit of Alternator		Primary Circuit of Transformer				Capacity in Microfarads	Discharge Circuit of Condenser		Liquid Medium	Level of Liquid above Spark in mm.	Speed of Alternator in Revolutions per Minute	Exposure in Minutes	Transformer Used
	Liquid	Air	Liquid	Air	Liquid	Air	Resistance in Ohms*	Current in Amperes	Resistance in Ohms*	Power in Watts	E. M. F. in Volts†	Current in Amperes		Self-Induction in Number of Turns	Fan Running					
604	0.3	5	**1.0**	4	*Fe*, flat	*Fe*, round	0	5.3	4	260	36	12.1	0.0029	0	Yes	Tap water	56	1570	18	General Electric
697	0.3	5	**1.6**	4	"	"	0	4.5	4	200	19	17.4	0.0029	0	"	"	56	1870	18	"
603	0.3	5	**2.3**	4	"	"	0	5.0	4	100	31	15.4	0.0029	0	"	"	56	1715	24	"
605	0.3	5	**4.0**	4	"	"	0	3.3	4	280	34	14.4	0.0029	0	"	"	56	1645	20	"
659	0.3	10	2.3	4	"	"	0	3.5	3	400	31	22.0	0.0066	**143**	"	"	56	1945	20	"
651	0.3	10	2.3	4	"	"	0	5.0	3	280	22	23.0	0.0066	**104**	"	"	56	1815	14	"
650	0.3	10	2.3	4	"	"	0	4.5	3	440	31	23.5	0.0066	**54**	"	"	56	1850	12	"
658	0.3	10	2.3	4	"	"	0	3.0	3	530	37	23.0	0.0066	**27**	"	"	56	1840	10	"
666	0.3	10	2.3	4	"	"	0	4.0	3	480	27	25.5	0.0066	**14**	"	"	56	1880	7	"
665	0.3	10	2.3	4	"	"	0	4.0	3	550	33	25.0	0.0066	**0**	"	"	56	1820	7	"
666	0.3	10	2.3	4	"	"	0	4.0	3	480	27	25.5	0.0066	**14**	"	"	56	1880	7	"
716	0.3	10	2.3	4	"	"	0	4.7	3	530	33	24.5	0.0066	**62 ft. Cu wire**	"	"	56	1880	6	"
658	0.3	10	2.3	4	"	"	0	3.0	3	530	37	23.0	0.0066	**27**	"	"	56	1840	10	"
672	0.3	1	2.3	2.3	"	Brass, flat	0	3.0	3	130	9	23.0	**0.0205**	0	"	"	56	1890	10	"
702	0.3	1	2.3	2.3	"	"	0	5.0	3	190	11	22.5	**0.0066**	0	"	"	56	1885	30	"
704	0.3	1	2.3	2.3	"	"	0	4.0	3	160	14	20.8	**0.0029**	0	"	"	56	1925	95	"
712	0.3	1	2.3	2.3	"	"	0	4.0	3	170	11	22.8	**0.0029**	0	"	"	56	1940	50	"
685	0.3	**15**	2.3	2.3	"	"	0	3.0	3	410	32	21.0	0.0066	0	"	"	56	1780	7	"
702	0.3	**1**	2.3	2.3	"	"	0	5.0	3	190	11	22.5	0.0066	0	"	"	56	1885	30	"
704	0.3	1	2.3	2.3	"	"	0	4.0	3	160	13	20.9	0.0029	0	"	"	56	1925	65	General Electric
705	0.3	1	2.3	2.3	"	"	0	4.5	3	170	12	22.6	0.0029	0	"	"	56	1980	75	Lakon 15000
710	0.3	1	2.3	2.3	"	"	0	4.0	3	240	15	21.6	0.0029	0	"	"	56	1870	55	Lakon 30000
717‡	0.3	10	2.3	4	"	*Fe*, round	22.5	3.0	**0**	370	15	38.0	0.0066	0	"	"	56	1975	8	General Electric
717	0.3	10	2.3	4	"	"	22.5	3.5	**3**	410	33	18.5	0.0066	0	"	"	56	1980	5	"
719‡	0.3	15	2.3	4	"	"	22.5	3.0	**4**	370	37	14.1	0.0029	0	"	"	56	2000	10	"
719	0.3	15	2.3	4	"	"	22.5	2.7	**0**	320	13	36.7	0.0029	0	"	"	56	1990	20	"
723	0.3	10	2.3	2.3	"	Brass, flat	**0**	5.0	4	240	21	18.6	0.0066	0	"	"	15	1945	18	Lakon 15000
725	0.3	10	2.3	2.3	"	"	**39**	2.0	4	300	38	10.5	0.0066	0	"	"	15	2045	10	"
726	0.2	15	2.3	4	"	*Fe*, round	**40.5**	2.0	4	370	88	7.1	0.0029	0	"	"	15	2075	20	"
727	0.2	15	2.3	4	"	"	**27**	2.5	4	120	64	10.6	0.0029	0	"	"	15	2005	11	"
767	**1.0**	6	2.3	4	"	"	0	4.5	4	400	45	17.8	0.0066	0	"	"	15	2075	20	"
772	**1.0**	6	2.3	4	"	"	0	4.0	4	430	51	15.8	0.0066	0	"	"	15		21	"
769	**0.6**	6	2.3	4	"	"	0	4.6	4	400	42	18.8	0.0066	0	"	"	15	1980	6	"
770	**0.6**	6	2.3	4	"	"	0	3.8	4	400	53	14.3	0.0066	0	"	"	15	1790	6	"
768	**0.3**	6	2.3	4	"	"	0	4.5	4	350	44	19.3	0.0066	0	"	"	15	1860	5.5	"
771	**0.3**	6	2.3	4	"	"	0	4.5	4	340	43	17.5	0.0066	0	"	"	15		5	"
694‡	0.1	3	2.3	4	"	"	0	4.0	2.2	500	33	24.0	0.0066	0	"	**2 NaCl**	56	1805	40	General Electric
695‡	0.1	3	2.3	4	"	"	0	4.0	2.2	280	14	26.0	0.0066	0	"	**Tap water**	56	1890	4	"

* Over and above resistance of field coils of alternator and primary winding of transformer respectively.

† Potential difference at terminals of transformer.

‡ Slit of spectroscope 0.050 mm.; 0.025 in all other cases.

There sometimes appear diffuse emission lines with rather prominent maxima of intensity; these may be regarded as combinations of types (1) and (2), or of types (1) and (3). Such lines, however, are not very well marked, nor of frequent occurrence.

B. *Absorption phenomena produced by changing the constants of the circuit.*—In passing from the bright-line to the dark-line condition, the various lines of the spectrum do not all act in the same way. In general, when an emission line appears on successive plates, it is either (1) progressively enhanced to a maximum, and then progressively shattered and weakened, or (2) the line is simply progressively shattered and weakened without noticeable enhancement. If reversal occur before shattering, the resultant line will be of types (5), (6), or (7). Such a line is at first characterized by weak absorption and strong emission components. With decreasing self-induction in the discharge circuit of the condenser the absorption line becomes much stronger, and the emission line fades away. The brightening of an emission line is usually most prominent on the plate just preceding the one on which the line shows a reversal.

When, on the other hand, a bright line is shattered to complete obliteration without enhancement, there ensues a balancing of emission and absorption, and later the line appears as an absorption line of type (4).

Certain lines—for example, λλ 3606.85, 3677.71, 3738.40, 3765.70, 3797.64, 3827.98, 3841.21, 3894.50, and 3898.05—are notably enhanced (relatively to other lines) in the spectrum of the spark in water, when considerable self-induction is used in the discharge circuit. There are undoubtedly a number of other lines thus enhanced, but these are among the most prominent.

C. *Shifts of the lines produced by changing the constants of the circuit.*—For various reasons, chief among which is the long exposure required with the concave grating when the spark is faint, many of the experiments undertaken in the qualitative investigation were not repeated with the high-dispersion spectroscope. Thus nothing further was done with regard to the water-pressure effect, (paragraph 14, p. 40), phenomena obtained with two or more water- or air-gaps in series (paragraphs 3 and 4, p. 38), the effect of change in the diameter of the air-gap terminals (paragraph 6, p. 39), and change in the temperature of the liquid (paragraph 8, p. 39).

There remain the cases presented in paragraphs 1, 2, 5, 7, 9, 10, 11, 12, and 13. In nearly every instance the results obtained with the low dispersion apparatus were confirmed. When this was not the case, the reasons for the difference in the results are evident. The conditions under which the different plates were taken are given in Table VII, and the specific results of each set in Tables VIII-XII inclusive.

(1) *Change in diameter of water-gap terminals.*—The shifts of the lines on Plates 604, 697, 603, and 605, taken with water-gap terminals of 1.0 and 1.6, 2.3, and 4.0 mm. in diameter, respectively, are shown in the following table (VIII). For many of the lines there seems to be a distinct and progressive change toward greater absorption and greater shift as the diameter of the terminals increases.

Change in length of water-gap.—The shifts of the lines as measured on Plates 767, 772; 769, 770; 768, 771 (three sets of duplicate plates), are given in Table IX. No certain progression is shown in the case of absorption lines, but there seems to be a gradual shift toward the red with increasing water-gap in the case of a few emission lines.

Change in length of air-gap.—Shifts of the lines on Plates 702 and 685 are given in Table IX. There seem to be many cases of genuine shifts toward the red with increasing air-gap.

Change of capacity.—The shifts of the lines as shown on Plates 712, 704; 702; and 672, are given in Table VIII. Within the range studied the changes are small and irregular and of no certain meaning. Plates 704 and 712 are unique. With conditions similar to those under which these were [illegible] (small capacity (0.003 microfarad), small air-gap (1 mm.), moderate water-gap (0.3 mm.)—see [illegible]) finally obtained spectra which contained numerous lines of types (8), (9), and (10). Lines

TABLE VIII

EFFECTS PRODUCED BY CHANGE IN DIAMETER OF WATER-GAP TERMINALS AND BY CHANGE OF CAPACITY

	CHANGE IN DIAMETER OF TERMINALS				CHANGE OF CAPACITY			
No. of Plate	604	697	603	605	701	712	702	672
Diameter of Terminals in mm. Capacity in Microfarads	1	1.6	2.3	4	0.003		0.007	0.020
Wave-Lengths	Intensities	Shift toward red in tenth-meters: positive unless otherwise stated. Type of line in *italics*. Absorption lines indicated by *a*; emission by *e*.						
3558.68	6	4 −0.03 *a*	4 0.00 *a*	4 −0.01 *a*	4 0.05 *a*	(Faint *a*)	(Faint *a*)	4 −0.01 *a*	4 0.01 *a*
65.54	8	5 − .02 *a*	4 .01 *a*	4 .01 *a*	4 .05 *a*	8 ——	8 0.02 *e* .02 *a*	4 − .01 *a*	4 − .02 *a*
87.10	5	4 − .01 *a*	4 .02 *a*	4 .05 *a*	4 − .01 *a*	4 0.00 *a*	(Faint *a*)	4 − .03 *a*	4 − .01 *a*
3606.85	6	8 .34 *e*	.....	7 − .09 *a*	.....	3 .17 *e*	3 .17 *e*	2 .17 *e*	7 .00 *a*
48.00	9	5 .01 *a*	5 .04 *a*	4 .04 *a*	4 .06 *a*	8 —— *e* .04 *a*	8 .04 *e* .02 *a*	4 − .05 *a*	.32 *e* 4 .00 *a*
51.60	4	2 .10 *e*							
80.06	5	4 − .01 *a*	4 .02 *a*	4 .02 *a*	4 .00 *a*	4 .03 *a*	4 .02 *a*	4 − .01 *a*	4 .03 *a*
87.55	6	7 − .01 *a* .34 *e*	7 .01 *a*	4 .01 *a* ——	4 .02 *a*	(Faint *a*)	(Faint *a*)	7 .00 *a* .33 *e*	4 .00 *a*
3709.40	6	6 − .02 *a* .38 *e*	6 .04 *a*	6 .04 *a*	4 .04 *a*	7 ——	7	7 .01 *a* .32 *e*	4 − .01 *a*
22.73	6	4 − .03 *a*	4 .01 *a*	4 .07 *a*	4 .09 *a*	4 .05 *a*	4 .07 *a*	4 − .01 *a*	4 .00 *a*
27.78	..	6 − .05 *a*	6 .00 *a*	4 .03 *a*	4 .02 *a*	(Faint *a*)	(Faint *a*)	5 .00 *a*	4 .01 *a*
33.46	6	4 − .03 *a*	4 .02 *a*	4 .02 *a*	4 .04 *a*	4 .03 *a*	4 .01 *a*	4 − .02 *a*	4 .02 *a*
43.51	7	7 − .04 *a* .29 *e*	7 − .01 *a* .35 *e*	4 .01 *a*	4 .03 *a*	7 ——	7 − .03 *a* .32 *e*	7 .02 *a* .31 *e*	7 .00 *a*
58.39	8	5 .00 *a*	4 .04 *a*	4 .05 *a*	4 .03 *a*	8 .02 *e* .04 *a*	8 − .01 *e* .05 *a*	6 .00 *a*	4 .00 *a*
63.91	7	5 .02 *a*	..... *a*	4 .02 *a*	4 .05 *a*	8 ——	8 − .01 *e* − .00 *a*	4 − .02 *a*	4 .01 *a*
65.70	5	2 .18 *e*	2 .19 *e*	3 .18 *e*	3 .29 *e*	3 .13 *e*	3 .15 *e*	2 .14 *e*	3 .15 *e*
67.32	7	6 − .02 *a*	6 .04 *a*	6 .04 *a*	4 .03 *a*	6 ——	6 .06 *a*	4 − .03 *a*	4 .00 *a*
95.15	6	5 − .06 *a*	5 .04 *a*	5 .02 *a*	4 .06 *a*	5 ——	5	5 − .04 *a*	4 .00 *a*
99.70	7	.....	6 − .01 *a*	6 .09 *a*	4 .00 *a*	(Lacking)	7 Very faint	7	4 − .02 *a*
3805.48	5	2 .08 *e*	2..... *e*	2 .15 *e*	2 .15 *e*				
15.99	9	6 .00 *a*	6 .03 *a*	6 .04 *a*	4 .05 *a*	8	8 − .01 *e* − .03 *a*	6 .01 *a*	4 .02 *a*
24.58	7	4 .00 *a*	4 .04 *a*	4 .05 *a*	4 .06 *a*	4 .07 *a*	4 .08 *a*	4 .03 *a*	4 .03 *a*
27.98	9	5 − .01 *a*	5 .05 *a*	4 .05 *a*	4 .09 *a*	8 ——	8	7 .03 *a* .48 *e*	6 .04 *a*
34.38	8	5 − .02 *a*	5 .04 *a*	4 .03 *a*	4 .01 *a*	8 ——	.03 *e* 8 .07 *a*	5 .00 *a*	4 .00 *a*
56.51	8	5 − .01 *a*	4 .03 *a*	4 .03 *a*	4 .04 *a*	4 .07 *a*	4	4 .01 *a*	4 .03 *a*

of this type require further study, as the method employed in measuring the position of the absorption part of the combination was unsatisfactory, owing to the fine thread required for other work with the measuring machine.

Change of self-induction in the discharge circuit.—The shifts obtained for measures of Plates 659, 651, 650, 658, 666, and 665 are given in Table X. Change of self-induction is much more satisfactory than any other means for controlling the absorption phenomena and the shifts of the lines. It also has the advantage of sharpening the lines, which results in increased accuracy of measurement. In the region under investigation the change from a bright line spectrum to one consisting almost wholly of absorption lines is nearly complete, though in the less refrangible region comparatively few lines are reversed, even when all self-induction is removed from the secondary circuit. (See Plate XIX.)

Wilsing's photograph of the iron spectrum in water, as far as can be judged from the description of the lines in his table (see Table I, p. 32), lies between our Plates 666 and 665 of the self-induction series. But according to line λ3765.70 (the central line of the triplet) the absorption is greater on his plate than on our No. 665 (for which no self-induction was used). On his plate

TABLE IX

EFFECTS PRODUCED BY CHANGE IN LENGTH OF WATER GAP AND AIR GAP

Number of Plate	CHANGE OF WATER-GAP									CHANGE OF AIR-GAP					
	765 and 772			769 and 770			768 and 771			762			685		
Water-gap (Plate 765–772) / Air-gap (Plate 762–685)	1.0			0.6			0.3			1			15		
Wave-length	Intensities	Shift toward red in tenth-meters; positive unless otherwise stated. Type of line in *italics*. Absorption lines indicated by *a*; emission line by *e*.													
3558.68	6				7	0.02	*a*	4	0.02	*a*	4	−0.01	*a*	4	0.04	*a*
							e									
65.54	8	5	−0.01	*a*	6	−.01	*a*	4	−.02	*a*	4	−.01	*a*	4	.02	*a*
87.10	5	6	.04	*a*	6	.00	*a*	4	.00	*a*						
3606.85	6	2	.17	*e*	2	.29	*e*	7	−.05	*a*	2	.17	*e*	7	.02	*a*
									.27	*e*					.32	*e*
46.54	5	2	.07	*e*	2	.11	*e*	2	.14	*e*						
48.89	9	5	.01	*a*	5	.02	*a*	4	.00	*a*	4	−.05	*a*	4	.03	*a*
51.60	4	2	.08	*e*	2	.12	*e*	2	.13	*e*						
80.06	5				4	.03	*a*	4	.02	*a*	4	.01	*a*	4	.02	*a*
87.55	6				6	.01	*a*	6	.00	*a*	7	.00	*a*	4	.01	*a*
												.33	*e*			
3709.40	6				6	.02	*a*	6	.02	*a*	7	.01	*a*	4	.03	*a*
												.32	*e*			
22.73	6	4	.01	*a*	5	.02	*a*	4	.02	*a*	4	−.01	*a*	4	.03	*a*
27.78					6	.02	*a*	6	.03	*a*	5	.00	*a*	4	.03	*a*
33.46	6	4	.03	*a*	4	.02	*a*	4	.03	*a*	4	−.02	*a*	4	.01	*a*
43.51	7				6	−.01	*a*	6	.03	*a*	7	.02	*a*	7	.02	*a*
												.31	*e*			*e*
58.39	8	5	.03	*a*	5	.02	*a*	4	.04	*a*	6	.00	*a*	4	.05	*a*
63.91	7	5	.02	*a*	5	.04	*a*	4	.05	*a*	4	−.02	*a*	4	.02	*a*
65.70	5	2	.10	*e*	2	.13	*e*	2	.18	*e*	2	.14	*e*	7	.02	*a*
															.27	*e*
67.32	7	6	.01	*a*	6	.02	*a*	6	.03	*a*	4	−.03	*a*	4	.04	*a*
95.15	6										5	.04	*a*	5	.02	*a*
99.70	7															
3805.48	5	2	.09	*e*	2	.10	*e*	2	.11	*e*						
15.29	9	6	.04	*a*	6	.04	*a*	6	.05	*a*	6	.01	*a*	6	.01	*a*
24.58	7	4	.07	*a*	4	.05	*a*	4	.06	*a*	4	.03	*a*	4	.05	*a*
27.98	9	6	.09	*a*	6	.05	*a*	6	.04	*a*	7	.03	*a*	4	.07	*a*
												.48	*e*			
34.38	8	5	.02	*a*	5	.03	*a*	5	.03	*a*	5	.00	*a*	4	.02	*a*
56.1	8										4	.01	*a*	4	.05	*a*

λ 3705.70 is of type 7; while on our plate this line is of type 2. From this and other facts, to be mentioned later, it may perhaps be inferred that all lines do not move toward absorption in the same manner under different conditions; i. e., given two plates, taken under widely different conditions, showing *in general* the same absorption, upon these plates there may be some cases in which the same line is at a different stage of absorption.

Change of ohmic resistance in the discharge circuit.—Measures of the shifts of the lines of Plate 716, which are given in Table XI, show that the displacements are in general slightly greater than those of Plate 666 of the self-induction series. The absorption, however, appears to be somewhat less marked, and the lines are not as sharp as those of the plate taken with self-induction.

Change of resistance in field circuit of alternator.—Plates 723 and 725; also 726 and 727 (no measurements made).—Plate 725 (resonance) shows unmistakably greater absorption than 723. Plates 726 and 727 (as well as another set made under slightly different conditions) show no difference. This might perhaps be due to the small difference in resistance (40 and 27 ohms) and the unequal exposures (20 and 11 minutes) during which resistance changes are introduced owing to change in temperature of the wires.

TABLE X

EFFECT PRODUCED BY CHANGE OF SELF-INDUCTION

No. of Plate		659	651	650	658	666	665
Self-Induction in No. of Turns of Coil		143	104	54	27	14	6
Wave-Lengths	Intensities	Shift toward red in tenth-meters: positive unless otherwise stated. Type of line in *italics*. Absorption lines indicated by *a*; emission, by *e*.					
3558.68	6	2 **0.04** *e*	2 **0.03** *e*	2 **0.07** *e*	7 **−0.06** *a* **.27** *e*	7 **0.04** *a* ... *e*	4 **0.03** *a*
65.54	8	2 **.06** *e*	3 **.07** *e*	7 **−.08** *a* **.25** *e*	6 **−.00**	4 **.00** *a*	4 **.00** *a*
87.10	5	2 **.02** *e*	2 **.06** *e*	Faint *e*	7 **−.09** *a* .... *e*	4 **−.01** *a*	4 **−.01** *a*
3606.85	6	2 **.01** *e*	2 **.02** *e*	2 **.04** *e*	2 **.08** *e*	2 **.14** *e*	7 **−.01** *a* **.28** *e*
40.53	5	2 **.02** *e*	....	2 **.03** *e*	....	2 **.08** *e*	....
48.00	9	3 **.08** *e*	2 **.07** *e*	6 **−.05** *a* **.22** *e*	6 **−.03** *a*	4 **−.01** *a*	4 **.02** *a*
80.06	5	Faint *e*	Lacking	Faint *a*	4 **−.00** *a*	4 **.01** *a*	4 **.00** *a*
87.55	6	2 **.09** *e*	2 **.08** *e*	2 **.08** *e*	7 **−.02** *a* **.26** *e*	7 **−.02** *a* **.27** *e*	4 **−.01** *a*
3709.40	6	3 **.07** *e*	3 **.09** *e*	2 **.09** *e*	7 **.02** *a* **.28** *e*	7 **.02** *a* **.33** *e*	4 **.03** *a*
22.73	6	Faint	Faint	Faint	4 **±.00** *a*	4 **.02** *a*	4 **.01** *a*
27.78	..	2 **.08** *e*	2 **.09** *e*	2 **.13** *e*	6 **−.03** *a*	6 **−.03** *a*	4 **.01** *a*
33.46	6	Faint *e*	Lacking	4 **.02** *a*	4 **.03** *a*	4 **.02** *a*	4 **−.01** *a*
43.51	7	2 **.06** *e*	2 **.06** *e*	2 **.09** *e*	7 **−.06** *a* **.25** *e*	7 **−.03** *a* **.28** *e*	7 **−.01** *a* **.30** *e*
58.39	8	3 **.07** *e*	3 **.09** *e*	7 **−.05** *a* **.24** *e*	6 **.02** *a*	6 **.02** *a*	4 **.02** *a*
63.91	7	3 **.05** *e*	2 **.06** *e*	2 **.21** *e*	6 **.01** *a*	4 **.00** *a*	4 **.01** *a*
65.70	5	2 **.02** *e*	2 **.03** *e*	2 **.01** *e*	2 **.09** *e*	2 **.10** *e*	3 **.21** *e*
67.32	7	2 **.03** *e*	2 **.03** *e*	2 **.06** *e*	7 **.01** *a* **.32** *e*	7 **.01** *a* **.31** *e*	4 **.02** *a*
95.15	6	2 **.04** *e*	2 **.08** *e*	2 **.10** *e*	2 **.28** *e*	6 **−.02** *a*	6 **−.02** *a*
99.70	7	2 **.03** *e*	2 **.03** *e*	2 **.04** *e*	Faint *a*	7 **.01** *a* **.22** *e*	4 **.03** *a*
3815.99	9	3 **.05** *e*	3 **.07** *e*	3 **.12** *e*	6 **−.00** *a*	6 **.01** *a*	6 **.03** *a*
24.58	7	Faint	Faint	4 **.03** *a*	4 **.04** *a*	4 **.04** *a*	4 **.03** *a*
27.98	9	3 **.02** *e*	3 **.05** *e*	2 **.09** *e*	7 **−.01** *a* **.35** *e*	6 **−.00** *a*	4 **.02** *a*
34.38	8	2 **.03** *e*	2 **.07** *e*	2 **.14** *e*	6 **−.01** *a*	6 **.01** *a*	4 **.02** *a*
56.51	8	Faint *e*	Faint *e*	Faint *e*	4 **.01** *a*	4 **.02** *a*	4 **.02** *a*
4045.98	10	2 **.01** *e*	2 **.02** *e*	2 **.09** *e*	5 **.02** *a*	5 **.02** *a*	4 **.06** *a*
63.75	10	2 **.03** *e*	2 **.02** *e*	2 **.04** *e*	6 **.06** *a*	6 **.02** *a*	4 **.02** *a*
71.92	10	2 **.02** *e*	2 **.03** *e*	2 **.03** *e*	6 **−.03** *a*	6 **.03** *a*	4 **.05** *a*
4118.72	5	2 **.02** *e*	....	....	2 **.03** *e*	2 **.03** *e*	....
99.27	8	2 **.02** *e*	2 **.04** *e*	2 **.00** *e*	2 **.06** *e*	2 **.06** *e*	2 **.11** *e*
4294.32	6	2 **.02** *e*	2 **.02** *e*	....	2 **.02** *e*	2 **.06** *e*	Faint *e*
4308.06	10	2 **.02** *e*	3 **.05** *e*	2 **.06** *e*	6 **−.05** *a*	6 **−.01** *a*	6 **.02** *a*
25.94	10	3 **.02** *e*	3 **.04** *e*	2 **.03** *e*	6 **−.01** *a*	6 **−.03** *a*	6 **.01** *a*
83.71	10	3 **.05** *e*	3 **.05** *e*	2 **.15** *e*	6 **−.01** *a*	6 **−.01** *a*	6 **.02** *a*
4404.94	10	2 **.03** *e*	2 **.05** *e*	2 **.04** *e*	6 **−.11** *a*	6 **−.04** *a*	6 **.02** *a*
15.29	8	2 **.05** *e*	2 **.02** *e*	2 **.02** *e*	2 **.12** *e*	2 **.12** *e*	Trace of 7

Change of resistance in primary circuit of transformer: Plates 712, 719 (no measurements made).—No difference is apparent in either set. Here again the small difference between 0 and 3, and 0 and 4, ohms in the transformer circuit might perhaps explain the failure to obtain a difference.

Change of transformer: Plates 704, 705, 710 (no measurements made). The absorption shown upon the plate obtained with the Lakon transformer with the 30,000 volt connections is greater than that obtained with the 15,000 volt combination; and the Lakon 15,000 and Lewis Institute transformer plates are identical. The difference noted above consists mainly, but not wholly,

TABLE XI

EFFECT OF OHMIC RESISTANCE COMPARED WITH THAT OF SELF-INDUCTION

No. of Plate		716			666		
Ohmic Resistance and Self-Induction Conditions		18.5 meters No. 23 Copper Wire			14 Turns of Self-Induction Coil		
Wave Lengths	Intensities	Shift toward red in tenthom. ters; positive unless otherwise stated. Type of line in *Arcs*. Absorption lines indicated by *a*; emission by *e*					
3558.68	6	7	**0.01**	*a*	7	**−0.04**	*a*
			.31	*e*		.....	*e*
65.54	8	5	**.01**	*a*	4	**.00**	*a*
87.10	5	5	**.01**	*a*	4	**−.01**	*a*
3606.85	6	2	**.15**	*e*	2	**.14**	*e*
48.00	9	6	**.00**	*a*	4	**−.01**	*a*
80.06	5	4	**.01**	*a*	4	**.01**	*a*
87.55	6	6	**−.01**	*a*	7	**.02**	*a*
						.27	*e*
3709.40	6	7	**.00**	*a*	7	**.02**	*a*
			.34	*e*		**.33**	*e*
22.73	6	4	**.01**	*a*	4	**.02**	*a*
27.78		6	**.01**	*a*	6	**.03**	*a*
34.46	6	4	**−.01**	*a*	4	**.02**	*a*
43.51	7	7	**.02**	*a*	7	**−.03**	*a*
			.28	*e*		**.28**	*e*
58.39	8	4	**.02**	*a*	6	**.02**	*a*
63.91	7	6	**.01**	*a*	4	**.00**	*a*
65.70	5	2	**.13**	*e*	2	**.10**	*e*
67.32	7	6	**.00**	*a*	7	**.01**	*a*
						.31	*e*
99.70	7	7	**.01**	*a*	7	**.01**	*a*
			.31	*e*		**.22**	*e*
3815.99	9	6	**.00**	*a*	6	**.01**	*a*
24.58	7	4	**.08**	*a*	4	**.04**	*a*
27.98	9	6	**.05**	*a*	6	**.00**	*a*
34.38	8	6	**.00**	*a*	6	**.01**	*a*
56.51	8	4	**.05**	*a*	4	**.02**	*a*

interchanges from types of lines Nos. 8, 9, and 10 (strong, sharp, bright lines in the center of absorption lines), with the Lewis Institute and Lakon 15,000 instruments, to types in which the bright line is weak or, like types 5, 6, and 7, wholly lacking—this in the case of the Lakon with 30,000 volt connections.

From data at hand it cannot be stated whether one transformer will always give more or less absorption than another. All that can be said is that regular differences occur, and that the plates showing such differences can usually be repeated. It may be seen in Table VII that the power in watts was about the same for plates 704 and 705, but considerably greater for 710, the plate which shows the greatest absorption.

From general considerations it might seem that the total power consumed in the gap would determine the amount of the absorption displayed by the spectrum. By referring to Table VII, and

by studying the character of the spectra as denoted by shift and absorption in Tables VIII–XI, it may be seen that the greatest absorption usually accompanies the highest readings of the watt meter.

But we note that this is not true in the plates of the self-induction series. This points to the fact that the suddenness of the discharge is an important factor in determining the absorption. Self-induction lengthens the time of the discharge, and the result is an emission spectrum.

At this point we may also give the results obtained with the *2 per cent. salt solution* when high dispersion was employed. Plates 694 and 695 (Table XII) were taken under identically the same conditions, except that the liquid used in the latter case was tap water, while for Plate 694 a 2 per cent. sodium chloride solution in tap water was used. Both plates were measured twice with considerable care. All but four of the lines measured show displacements toward the red in the salt solution as compared with their positions in the tap water. Moreover, λ 3827.98, which is one of the lines not displaced, acts abnormally in Plates 767–772 (length of water-gap series), where it does not follow the general rule, but shows greater shift at less absorption.

TABLE XII

TAP WATER AND 2 PER CENT. SALT SOLUTION

Comparison of duplicate measurements of Plates 694 and 695; $\Delta\lambda_1$ and $\Delta\lambda_2$, the means of the same; and $\Delta\lambda_1 - \Delta\lambda_2$, or the excess displacement in the salt solution over that in the tap water.

No. of Plate		694					695					$\Delta\lambda_1 - \Delta\lambda_2$
Liquid Used		2 per cent. *Na Cl* Solution					Tap Water					
Wave-Lengths	Intensities	Displacements Measurement No. 1	Displacements Measurement No. 2	Mean $\Delta\lambda_1$	Types of Lines		Displacements Measurement No. 1	Displacements Measurement No. 2	Mean $\Delta\lambda_2$	Types of Lines		
3687.55	6	0.01	0.01	0.010	4	a*	0.00	0.00	0.000	4	a*	0.010
3708.06	5	.01	.00	.005	4	a	− .03	− .04	− .035	7	a	.040
									.....		e	
58.39	8	.01	.00	.005	5	a	.00	.01	.005	4	a	.000
63.91	7	.03	.03	.030	4	a	.00	.00	.000	4	a	.030
65.70	5	.27	.27	.270	2	e	.17	.19	.180	2	e	.090
67.32	7	.03	.05	.040	4	a	.01	.02	.015	4	a	.025
88.02	5	− .01	.00	− .005	4	a	.01	− .01	.000	4	a	−.005
99.70	7	.04	.01	.025	4	a	.03	.03	.030	4	a	−.005
3805.48	5	.05	.23	.240	3	e	.12	.13	.125	3	e	.115
13.12	5	.01	.01	.010	4	a	.00	− .02	− .010	4	a	.020
27.98	9	.03	.03	.030	4	a	.03	.04	.035	4	a	−.005
34.38	8	.03	.03	.030	4	a	− .02	− .01	− .015	4	a	.045
4045.98	10	.04	.03	.035	4	a	.01	.02	.015	4	a	.020
63.75	10	.07	.08	.075	4	a	.01	.00	.005	4	a	.070
4308.06	10	.03	.04	.035	4	a	− .02	.00	− .010	6	a	.045
25.94	10	.02	.01	.015	4	a	− .02	− .02	− .020	6	a	.035
83.71	10	− .01	.00	− .005	6	a	− .03	− .02	− .025	6	a	.020
4404.94	10	.02	.03	.025	6	a	− .07	− .06	− .065	6	a	.090

*a signifies absorption line; e emission line.

The spectrum of a *rotating arc* (direct current, 110 volts) between iron electrodes in water showed a bright line spectrum, marked by a few lines not present in air and therefore probably due to the surrounding liquid. No absorption lines were shown. From a plate taken at low dispersion, in the qualitative part of this investigation, it was found that the spectrum of the Wehnelt break (iron and lead in potassium hydroxide) similarly contains no absorption lines in the region examined.

The question naturally arises: Does a definite displacement correspond to a definite degree of absorption for any given liquid, no matter how different may be the electrical conditions under which the two plates giving the same absorption are obtained? Plate 716 (in which resistance was inserted

in the discharge circuit of the condenser) shows slightly less absorption than Plate 666. It falls between Plates 666 and 658. In amount of shift six lines lie between 658 and 666, and sixteen lines lie above 666. Apparently the facts are not such as would justify any general conclusion, for the number of lines studied is too small. Reference may be made, however, to many marked differences between the shifts observed by Wilsing and by ourselves, on plates showing nearly the same degree of absorption (p. 32).

DISCUSSION OF RESULTS OBTAINED WITH THE SPARK IN LIQUIDS

When a high-potential discharge takes place between metallic poles in liquids, two causes unite to produce a very rapid increase of pressure in the immediate neighborhood of the poles: (1) the sudden production of a very high temperature, and (2) the sudden production of metallic vapor shot out from both poles. At each discharge a pressure wave moves out from the poles, the maximum pressure produced and the pressure gradient depending upon a variety of circumstances, chief among which are the nature of the discharge, the physical and chemical properties of the liquid and the character of the metal of which the poles are composed. Let us consider briefly the bearing of these various factors upon the resultant effect.

The pressure as affected by the character of the discharge.— From the investigations of Schuster and Hemsalech we know that the character of the discharge of the condenser is very different under different conditions in the circuit. When the resistance and self-induction of the circuit are very small, almost all the energy passes in the initial discharge. When water resistance is inserted in the circuit, it produces an intermittent discharge in which but little vapor is given off from the poles. The introduction of self-induction produces an oscillatory discharge, which is rendered comparatively slow by the opposing currents induced in the self-induction coil. Under these latter circumstances the initial discharge becomes more feeble, and the succeeding oscillations more marked and slower. The bearing of these results of Schuster and Hemsalech upon the pressure phenomena encountered in the present investigation is sufficiently obvious. As we have shown, the highest pressures are obtained when the resistance and self-induction of the discharge circuit are very small—i. e., under circumstances which tend to concentrate the energy in the first discharge. When water resistance is introduced, the spectroscopic phenomena entirely correspond with such a change in the spark as would involve loss of energy and less vaporization of the metallic poles. Self-induction in the circuit not only tends to reduce the energy of the discharge, but also makes it less sudden, on account of the distribution of the energy over the successive oscillations. We should therefore expect a very marked effect of self-induction upon the spectroscopic phenomena, and this is fully realized in practice.

The marked change in the spectrum produced by increasing the length of the spark in the liquid would seem to indicate that the energy of the discharge is greatly decreased in this way. After it had been noticed that the terminals wear away rapidly with a water-spark from 0.1 mm. to 0.3 mm. long, and slowly with a spark from 0.8 mm. to 1.0 mm. long, it was thought that the great difference in the amount of vapor produced under the two conditions might account for the observed differences in the spectrum. However, the experiments described on page 44 clearly prove that the effect is not confined to the spectrum of the spark under observation, but may be produced by changing the length of a second liquid spark, in series with the first. It thus appears that the effect is probably due to a decrease in the energy of the discharge, which may be brought about by the insertion of a liquid resistance in any part of the discharge circuit.

The effect of changing the length of the air-gap is what might have been anticipated, as the potential of the discharge is thus increased, and this results (for any given capacity) in an increase in the quantity of electrical energy involved in each discharge. An increase in the diameter of the air-gap or water-gap terminals would also tend to increase the potential of the discharge, though in the latter case the effect of increased absorption is more probably due to a restriction of the volume

occupied by the vapor and a consequent increase in its density owing to the more extensive boundary walls of the larger terminals.

An increase of capacity would be expected to increase the energy of the discharge, and therefore to produce increased absorption, such as we have observed to occur.

The effect of self-induction and of ohmic resistance in the discharge circuit has already been mentioned. In both cases the results were what one would expect.

The effects produced by varying the field resistance of the alternator, the resistance in the primary circuit of the transformer, or of changing the transformer itself, probably arise from the influence of such changes upon the energy involved in each discharge and the degree of disruptiveness produced in the spark.

The three properties of liquids which seem to be most directly concerned are (1) the density, (2) the electrical conductivity, and (3) the tendency to unite chemically with the metal of the electrodes.

1. Other things being equal, the degree of absorption would presumably increase with the density of the liquid; but differences of conductivity, and of the chemical effects of different liquids, frequently mask effects caused by differences of density alone.

2. We should expect, with a liquid of considerable electrical conductivity, that the increased leakage between the terminals would tend to reduce the potential of the discharge, and therefore its energy. The experiments already described with liquids of different conductivities do not seem to conflict with this view. It is true that when the concentration of a salt solution is increased, thereby, in general, increasing its conductivity, the absorption phenomena become more marked. But it has been shown that this is probably due to increased chemical action between the liquid and the electrodes, which would tend to produce a greater volume of vapor, and thus to offset the loss arising from leakage between the terminals.

3. We were led by our spectroscopic experiments to the conclusion that the presence of a salt in the solution causes the metal of the terminals to vaporize more rapidly. This was before we had become acquainted with the work of Bredig and Haber, who reached the same conclusion, after studying the pulverization of the electrodes by an entirely different method, involving no spectroscopic observations.

II. THE SPECTRUM OF THE HIGH POTENTIAL DISCHARGE BETWEEN METALLIC ELECTRODES IN GASES AT HIGH PRESSURES

In connection with the early part of this investigation, the blue region of the iron spectrum of the transformer spark in air was observed at pressures up to 20 atmospheres. The measured values of the shifts harmonized fairly well with those of Humphreys and Mohler, obtained with the arc at lower pressures. The metallic lines remained fairly sharp and were shifted toward the red by an amount which seemed to be directly proportional to the pressure (Plate XXII).

In his paper "On the Interpretation of the Typical Spectrum of the New Stars,"[20] Professor Wilsing concludes that the pressure resulting from the spark discharge in liquids amounts to several hundred atmospheres. As our own investigations led us to the belief that the pressure, at least in the case of our iron spark, was in reality much lower, we thought it desirable to extend our earlier work on spark spectra in air at high pressures to the more refrangible region studied in the case of liquids. As the apparatus previously used for such work proved inadequate, a new pressure tank was constructed in the Observatory instrument shop, and with this no difficulty was experienced in photographing the spectrum of the iron spark in gases at pressures ranging from 1 to 53 atmospheres.

This pressure tank was made of two cylindrical pieces of steel 11 cm. and 13 cm. long respectively, and 8.5 cm. in diameter. One of these was threaded, the other tapped, and both were bored

[20] *Astrophysical Journal*, Vol. X (1899), p. 113.

out so that the inclosed chamber was 16 cm. long and 5.5 cm. in diameter. The spark was produced between terminals screwed on rods, which were arranged as in the brass tank used in the investigation of the discharge in water, except that the ebonite insulators were conical and were set in cone-shaped receptacles to withstand high pressures. The light from the spark passed through a glass window, which had an aperture of 8 mm. and was 5 mm. thick. This also was cone-shaped to prevent its blowing out. Nut-heads were cut on each end of the cylinder, and special wrenches were made to screw and unscrew the two parts. A copper washer rendered the instrument air-tight. The receptacle was tapped for outlet, inlet, and pressure gauge. The compressed air and carbon dioxide were led in by a spiral tube from high-pressure tanks. When carbon dioxide was used, the window was taken off, and the gas allowed to escape freely for ten seconds before the tank was closed.

The accessory air-spark was always employed; without it the discharge was intermittent at best and often refused to pass at all. The secondary potential difference in certain cases ran as high as 19,000 volts in actual operation.

As stated above, the spectra photographed in the earlier work at high pressures did not extend into the ultra-violet. It had been shown that the reversals of the lines in the case of spark spectra in liquids appear first in the ultra-violet, and advance gradually toward the less refrangible region as the conditions for reversal become more favorable. A similar result was shown many years ago by Liveing and Dewar to obtain in the case of arc reversals. It is for this reason that the phenomena to be described were not encountered by us in our earlier work at lower pressures on the less refrangible region of the spectrum of the iron spark in air. Nevertheless, we were somewhat surprised to find, in our first test of the new apparatus, that at an air pressure of 14 atmospheres the reversal phenomena in the region $\lambda 3550$ $\lambda 4500$ closely resembled those we were accustomed to photograph in the case of the iron spark in water with but little self-induction in the discharge circuit. It was at once evident that a series of photographs made at different air pressures would resemble the series previously obtained with the spark in water by varying the self-induction. Photographs were therefore made at pressures ranging from 1 to 53 atmospheres, portions of which are reproduced in Plate XXI. In the temporary absence of compressed air at pressures greater than 14 atmospheres, liquid carbon dioxide was used to give higher pressures. It has since been found, moreover, that changes of self-induction in the discharge circuit of the condenser affect the reversal phenomena in the same sense as in the case of the spark in water, but over a smaller range.

An examination of Plate XXI will show that the phenomena closely resemble those described in the case of liquids (see p. 51). At an air pressure of 3.3 atmospheres the lines are for the most part bright, though a few cases of reversal appear. It will be noticed that a few of the lines have at this stage increased very markedly in relative intensity. Such lines, as the subsequent photographs show, pass through a maximum of intensity and afterward reverse. At a pressure of 7.3 atmospheres the bright lines are broader and more diffuse, and the absorption lines are becoming prominent. It is evident from inspection that many of the reversals are not symmetrical, the bright line being relatively displaced toward the red. At a pressure of 14 atmospheres the dark lines have become very conspicuous, and many of the bright lines have almost disappeared. Some evidences of a continuous spectrum begin to appear at this pressure. At 27.3 atmospheres (in carbon dioxide) the continuous spectrum is quite conspicuous. The absorption lines are strong, and the bright lines are much fainter than before. At 53.3 atmospheres (also in carbon dioxide) the bright lines have practically disappeared in this region and the dark lines remain, broad and diffuse, on a background of bright continuous spectrum. At this pressure most of those lines whose intensity is increased at moderate pressures are reversed, and the relative intensities of all the dark lines closely resemble those of the bright lines in the spectrum of the iron spark at atmospheric pressure. Even at the highest pressures used, if any lines less refrangible than $\lambda 4415$ are reversed. In the region $\lambda 4800$ $\lambda 4900$ there are several strong lines unsymmetrically broadened in carbon dioxide at 53.3 atmospheres, and similarly

affected in water. It seems to be true that the order in which various lines reverse is not always precisely the same in gases as in liquids. For instance, line *A* may be an absorption line in water when line *B* is an emission line, while in air line *A* may be bright when *B* is dark. With the spark in air at pressures somewhat greater than one atmosphere the noticeable effect is generally an enhancement of the lines. The spark increases in brilliancy and becomes very disruptive; moreover, the air lines disappear at comparatively low pressures.

A preliminary study of the shifts of the bright and dark lines at these various pressures has brought out certain facts, which are of interest in connection with the results obtained by Humphreys and Mohler on the low potential discharge in air at high pressures, and our own results on the spectra of high potential discharges in liquids.

The following tables contain data concerning several plates and show the displacements of a few lines which may be regarded as fairly typical.

Table XIII gives the pressure and the constants of the electrical circuit which were used in the various cases.

TABLE XIII

PHYSICAL AND ELECTRICAL CONDITIONS DURING EXPOSURES. IRON TERMINALS IN AIR AND CARBON DIOXIDE UNDER PRESSURE

No. of Plate	Length of Gaps in mm.		Diameter of Terminals in mm.		Metal and Shape		Field Circuit of Alternator		Primary Circuit of Transformer				Capacity in Microfarads	Discharge Circuit of Condenser		Exposure in Seconds	Transformer Used	Medium	Pressure in Atmospheres‡
	Gas under Pressure	Air	Gas under Pressure	Air	Gas under Pressure	Air	Resistance in Ohms*	Current in Amperes	Resistance in Ohms*	Power in Watts	E.M.F. in Volts†	Current in Amperes		Self-Induction in No. of Turns of Coil	Fan Running				
842	0.6	5	2.3	4	*Fe*, flat	*Fe*, r'nd	0	5.5	4	200	23	24	0.007	0	Yes	50	Lakon 15,000	AIR	3.3
839	1.1	5	2.3	4	"	"	0	5.2	4	270	27	20	0.007	0	"	70	"	"	7.3
833	0.2	5	2.3	4	"	"	0	...	4	...	..	..	0.007	**0**	"	40	"	"	**14.0**
837	0.3	5	2.3	4	"	"	0	5.0	4	170	17	23	0.007	**143**	"	60	"	"	**14.0**
859	0.2	5	2.3	4	"	"	0	3.5	4	150	17	17	0.007	0	"	240	"	CO_2	3.7
858	0.3	5	2.3	4	"	"	0	4.0	4	270	31	21	0.007	0	"	90	"	"	7.7
856	0.3	5	2.3	4	"	"	0	...	4	...	..	..	0.007	0	"	50	"	"	**14.0**
855	0.3	5	2.3	4	"	"	0	...	4	...	..	..	0.007	0	"	35	"	"	**26.7**
857	0.3	5	2.3	4	"	"	0	...	4	...	..	..	0.007	0	"	25	"	"	**51.7**
864§	0.3	5	2.3	4	"	"	0	...	4	...	..	..	0.007	0	"		"	CO_2	

* Resistance over and above that of field coils of alternator and primary windings of transformer.

† Potential difference at terminals of transformer.

‡ Pressure as measured by gauge, in excess of normal atmospheric pressure.

§ Comparison spectrum inside, pressure spectrum outside.

Table XIV shows the effect of *increase of pressure*, using *air* as the gaseous medium. Plates 833 and 837 also show the result of placing self-induction in the discharge circuit of the condenser. As stated above, the influence of self-induction is not so marked as in the case of the spark in water.

Table XV deals with the effect of *increase of pressure*, with *carbon dioxide* as the gaseous medium. Plate 864 is to be compared with 858, the former being taken with the position of the spark spectrum at normal pressure and that of the comparison spectrum under approximately 7 atmospheres, reversed on the photographic plate. This was done to determine whether or not the shifts were genuine, and not due to unsymmetrical broadening. In measuring 864 the cross-hairs of the comparator were set upon the tips of the lines of the spectrum of the spark under pressure.

TABLE XIV

EFFECT PRODUCED BY CHANGE OF PRESSURE

AIR

No. of Plate		842		839		833		837*	
Pressure in Atmospheres*		3.3		7.3		14		14	
Wave Lengths	Intensities	Shift toward red in tenth-meters: positive unless otherwise stated. Absorption lines indicated by *a*; emission lines by *e*.							
3587.10	5	2	**0.05** *e*	6	**−0.01** *a*	6	**−0.01** *a*		
3606.85	6	2	**.06** *e*	2	**.14** *e*	7	**.05** *a* **.39** *e*	2	**0.26** *e*
3733.46	6	2	**.07** *e*	4	**.01** *a*	4	**.02** *a*	4	**.01** *a*
58.39	8	6	**.01** *a*	6	**.06** *a*	6	**.08** *a*		
65.70	5	2	**.09** *e*	2	**.15** *e*	7	**.05** *a* **.33** *e*	2	**.16** *e*
67.32	7	2	**.09** *e*	6	**.06** *a*	6	**.07** *a*	6	**.05** *a*
3815.99	9	6	**.04** *a*	6	**.05** *a*	6	**.08** *a*	6	**.07** *a*
24.58	7	2	**.03** *e*	5	**.07** *a*	4	**.04** *a*	4	**.06** *a*
27.98	9	2	**.11** *e*	6	**.06** *a*	6	**.10** *a*	6	**.08** *a*
34.38	8	2	**.10** *e*	6	**.06** *a*	6	**.08** *a*	6	**.07** *a*
4045.98	10	5	**.03** *a*	5	**.05** *a*	5	**.07** *a*		
63.75	10	2	**.07** *e*	5	**.06** *a*	5	**.07** *a*		
4199.27	8	2	**.05** *e*	2	**.14** *e*	2	**.18** *e*		
4294.32	6	2	**.04** *e*	2	**.09** *e*	2	**.16** *e*		
4308.06	10	2	**.09** *e*	5	**.08** *a*	5	**.09** *a*		
25.94	10	2	**.07** *e*	5	**.04** *a*	5	**.10** *a*		
83.71	10	6	**.01** *a*	6	**.03** *a*	6	**.10** *a*		
4404.94	10	2	**.03** *e*	6	**.06** *a*	6	**.12** *a*		

* In excess of normal atmospheric pressure.

† 142 turns of self-induction coil in discharge circuit of condenser.

TABLE XV

EFFECT PRODUCED BY CHANGE OF PRESSURE

CARBON DIOXIDE

No. of Plate		859		858		856		855		857		864*	
Pressure in Atmospheres		3.7		7.7		14		26.7		51.7		7.3	
Wave Lengths	Intensities	Shift toward red in tenth meters. Type of line in *italics*. Absorption lines indicated by *a*; emission lines, by *e*.											
3587.10	5	2	**0.02** *e*	2	**0.04** *e*	7	**0.06** *a* **.35** *e*	4	**0.08** *a*	4	**0.10** *a*	2	**0.06** *e*
3606.85	6	2	**.04** *e*	2	**.08** *e*	2	**.20** *e*	4	**.08** *a*	4	**.12** *a*	2	**.10** *e*
3733.46	6	2	**.03** *e*	2	**.04** *e*	4	**.02** *a*	4	**.06** *a*	4	**.06** *a*	2	**.06** *e*
58.39	8	2	**.07** *e*	6	**.02** *a*	6	**.04** *a*	4	**.07** *a*	4	**.14** *a*	6	... *a*
65.70	5	2	**.05** *e*	2	**.07** *e*	2	**.16** *e*	4	**.10** *a*	4	**.13** *a*	2	**.09** *e*
67.32	7	2	**.04** *e*	2	**.06** *e*	6	**.05** *a*	6	**.09** *a*	4	**.11** *a*	2	**.10** *e*
3815.99	9	2	**.06** *e*	6	**.05** *a*	6	**.06** *a*	4	**.10** *a*	4	**.14** *a*	6	... *a*
24.58	7	2	**.00** *e*	2	**.03** *e*	5	**.04** *a*	4	**.07** *a*	4	**.08** *a*	5	... *a*
27.98	9	2	**.06** *e*	2	**.10** *e*	6	**.08** *a*	6	**.11** *a*	4	**.16** *a*	2	**.15** *e*
34.38	8	2	**.05** *e*	2	**.08** *e*	6	**.06** *a*	6	**.09** *a*	4	**.16** *a*	5	... *a*
4045.98	10	2	**.03** *e*	5	**.04** *a*	5	**.04** *a*	5	**.10** *a*	4	**.14** *a*		
63.75	10	2	**.03** *e*	2	**.04** *e*	5	**.07** *a*	5	**.11** *a*	4	**.18** *a*		
4199.27	8	2	**.03** *e*	2	**.06** *e*	2	**.11** *e*	2	Very diffuse	Lacking			
4294.32	6	2	**.02** *e*	2	**.02** *e*	2	**.08** *e*	2	**.22** *e*	2	Faint & diff.		
4308.06	10	2	**.05** *e*	2	**.10** *e*	5	**.09** *a*	5	**.10** *a*	5	**.17** *a*		
25.94	10	2	**.06** *e*	2	**.06** *e*	5	**.06** *a*	5	**.12** *a*	5	**.15** *a*		
83.71	10	2	**.03** *e*	6	**.05** *a*	6	**.06** *a*	6	**.08** *a*	6	**.15** *a*		
4404.94	10	2	**.04** *e*	2	**.08** *e*	2	**.04** *a*	6	**.10** *a*	6	**.11** *a*		

* [illegible] of [illegible]

A study of the pressure shifts[21] of the lines in the tables indicates:

1. That the shifts of certain bright lines, which remain fairly sharp and show no sign of reversal at high pressures, vary directly as the pressure.

2. That the shifts of certain bright lines at high pressures appear to be less than the law of direct proportionality would require.

3. That the shifts of certain dark lines increase directly with the pressure, though the shift per atmosphere is usually less than in the case of bright lines.

4. That when, with increasing pressure, a bright line is first accompanied and subsequently replaced by a dark line, the presence of the dark line appears to increase the shift of the bright line abnormally in the first instance, whereas the shift of the dark line, after the disappearance of the bright line, is usually comparatively small, and increases with the pressure.

The absorption and shifts, as apparent on 864 (7.3 atmospheres) are both slightly greater than those on 858 (7.7 atmospheres). This is contrary to the general law: greater pressure, greater absorption and shift. It indicates that the results may not be very reliable, and throws doubt on the conclusion, suggested by a comparison of Tables XIV and XV, that for a given pressure the air plates show respectively greater absorption and shift than the corresponding carbon dioxide plates.

Table XVI gives a comparison of the effects of increasing pressure in the case of the spark in air, and of decreasing self-induction in the case of the spark in water. Plate 659 (water) shows a trifle less absorption than 842 (air). It will be noticed that the values of the shift are distinctly less. The same is true of the other pairs, 658, 839; and 665, 833: in all three sets the water plate shows a little less absorption but considerably less shift. Determining the means of the measured shifts of the emission and absorption lines, we obtain the data given in Table XVII. In these three sets the pairs of plates in each show very nearly the same spectrum. If we assume that the pressure developed in the spark under water determines the shift, we may calculate the pressure. From the first set, Plates 842 and 659, using the emission lines only, the pressure in the water-spark is found to be 1.4 atmospheres; from the second set, Plates 839 and 658, 3.5 atmospheres; and from the third set, Plates 833 and 665, 9.1 atmospheres. Of course, the above assumption may not be justifiable.

The variation in the shift and absorption in the high-pressure air plates, taken under what appeared to be identical conditions, may be due to differences in the length of the internal gap, which could not be adjusted accurately and therefore widened rapidly during the exposure.

Two sets of plates, using for one member of each set metal terminals made from a nickel five-cent piece (25 per cent. nickel and 75 per cent. copper), and for the other approximately chemically pure nickel, seem to show that less absorption is given by the alloy than by the pure metal. The gas used was carbon dioxide, and the pressure approximately 14.3 atmospheres for the first set and 20 for the second.

At pressures above 50 atmospheres the air-lines are not present in the spectrum photographed.

Further results of this part of the investigation are as follows:

As previously mentioned, the influence of self-induction lies in the same direction as with the spark in water, but the effect is less marked. On the other hand, the effect of an increase in the length of the *auxiliary gap* appears to be great, tending toward extreme absorption. The iron line λ 3765.70 is clearly of type 7 (absorption line superposed on emission but with the violet component of the latter lacking) on a plate taken at high dispersion under a pressure of 13.3 atmospheres with an auxiliary gap of 20 mm. This line is not usually reversed.

In our experiments with gases under pressure it was possible to carry the absorption farther toward the red end of the spectrum than with the discharge in liquids. The iron line λ 4415.29 at 27.3 and 53.3 atmospheres' pressure in carbon dioxide is clearly of type 6 (unsymmetrically reversed;

[21] The measurements of these shifts are frequently liable to errors of several hundredths of a tenth-meter, due in part to the character of the lines.

TABLE XVI

COMPARISON OF SHIFT SHOWN BY "AIR" AND "WATER" PLATES WHICH SHOW SIMILAR DEGREES OF ABSORPTION

No. of Plate	842 Air	659 Water	839 Air	658 Water	833 Air	665 Water
Pressure in Atmospheres* and Inductance, No. of Turns	3.3	11.5	7.3	27	14.0	0

Wavelengths	Intensities	Shift toward red in tenth-meters; positive unless otherwise stated. Absorption lines indicated by *a*; emission lines by *e*.					
3587.10	5	2 **0.05** *e*	2 **0.02** *e*	6 **−0.01** *a*	7 **−0.09** *a* — *e*	6 **−0.01** *a*	4 **−0.01** *a*
3906.85	6	2 **.06** *e*	2 **.01** *e*	2 **.14** *e*	2 **.08** *e*	7 **.05** *a* **.39** *e*	7 — **.01** *a* **.28** *e*
3733.46	6	2 **.07** *e*	2 — *e*	1 **.01** *a*	4 **.03** *a*	4 **.02** *a*	4 — **.01** *a*
58.39	8	4 **.01** *a*	3 **.07** *e*	6 **.06** *a*	6 **.02** *a*	6 **.08** *e*	5 **.02** *a*
65.70	5	2 **.09** *e*	2 **.02** *e*	2 **.15** *e*	2 **.09** *e*	7 **.05** *a* **.33** *e*	3 **.21** *e*
67.32	7	2 **.09** *e*	2 **.03** *e*	6 **.08** *a*	7 **.01** *a* **.32** *e*	6 **.07** *a*	4 **.02** *a*
3815.99	9	6 **.04** *a*	3 **.05** *e*	6 **.05** *a*	6 **.00** *a*	6 **.08** *a*	6 **.03** *a*
24.58	7	2 **.03** *e*	Lacking	5 **.08** *a*	4 **.04** *a*	4 **.04** *a*	4 **.03** *a*
27.98	9	2 **.11** *e*	3 **.02** *e*	6 **.06** *a*	7 — **.01** *a* **.35** *e*	6 **.10** *a*	4 **.02** *a*
34.38	8	2 **10** *e*	2 **.03** *e*	6 **.06** *a*	6 — **.01** *a*	6 **.08** *a*	4 **.02** *a*
4045.98	10	5 **.03** *a*	2 **.01** *e*	5 **.05** *a*	6 **.02** *a*	5 **.07** *a*	4 **.06** *a*
63.75	10	2 **.07** *e*	2 **.03** *e*	5 **.06** *a*	6 **.06** *a*	5 **.07** *a*	4 **.02** *a*
4139.27	8	2 **.05** *e*	2 **.02** *e*	2 **.14** *e*	2 **.06** *e*	2 **.18** *e*	2 **.11** *e*
4294.32	6	2 **.04** *e*	2 **.02** *e*	2 **.09** *e*	2 **.02** *e*	2 **.16** *e*	2 —— *e*
4308.06	10	2 **.09** *e*	2 **.02** *e*	5 **.08** *a*	6 **.05** *a*	5 **.13** *a*	6 **.02** *a*
25.94	10	2 **.07** *e*	3 **.02** *e*	5 **.04** *a*	6 — **.01** *a*	5 **.11** *a*	2 **.01** *e*
83.71	10	6 **.01** *a*	5 **.05** *e*	6 **.03** *a*	6 — **.01** *a*	6 **.10** *a*	6 **.02** *a*
4404.94	10	2 **.03** *e*	3 **.03** *e*	6 **.06** *a*	6 — **.11** *a*	6 **.12** *a*	6 **.02** *a*

*Above normal atmospheric pressure.

TABLE XVII

CALCULATION OF PRESSURE PRODUCED IN SPARK UNDER WATER

No. of Plate	842 Air 3.3	659 Water	839 Air 7.3	658 Water	833 Air 14.0	665 Water
Mean shift as determined from data given in Table XVI	0.068	0.028	0.130	0.063	0.170	0.110
Resultant calculated pressure in the spark under water	1.4 atmospheres		3.5 atmospheres		9.1 atmospheres	

see Plate XXI, which shows the maximum absorption given in these regions with the spark in carbon dioxide). In the spark under water, only the faintest shadow of a reversal could be obtained.

Our spectra of the spark in water and in air under pressure differ in the following details:

a) Some emission lines show reversal more easily in air than in water, while with other lines the reverse is true.

b) In water the lines of type 3 (unsymmetrically broadened emission lines) are more numerous than in air. However, as mentioned above, in the less refrangible regions near λλ 4880 and 4900 several strong lines occur which are unsymmetrically broadened. These are similarly affected in water under high absorption conditions.

c) In gases under pressure, the enhancement of certain lines previous to reversal is very marked.

d) The non-uniformity in the intensity of the continuous spectrum in the air plates under low absorption conditions is in marked contrast to the uniformity of intensity which obtains in the water

III. BEARING OF THE SPARK PHENOMENA ON THE PRESSURE THEORY OF TEMPORARY STARS

We have now to consider the bearing of our results on Wilsing's theory of temporary stars. In this theory Wilsing ascribes the chief characteristics of the spectra of *Novae* to pressure, and finds a close analogy between their spectra and that of the spark in water. The conditions of the laboratory experiments were such that his spark in water showed pairs of bright and dark lines, somewhat resembling in appearance the compound lines in the spectra of temporary stars. Wilsing suggests that luminescence phenomena may play some part in these stellar spectra; but he regards pressure as the prime factor, and as our results bear only on this point, we shall confine our conclusions to pressure effects.

It may be advantageous at this juncture to recall the chief phenomena of temporary stars, as exemplified in the case of *Nova Persei*. On February 21, 1901, a photograph of the constellation *Perseus* showed nothing unusual, and demonstrated that no unknown star as bright as the twelfth magnitude could be present. The next night the *Nova* was discovered visually by Anderson, who estimated its magnitude to be 2.7. The brightness rose to a maximum of 0 mag. on February 23, and then decreased steadily to a minimum of about 1.8 mag. on February 28, after which it rose, in a few hours, to about 1.6 mag. Subsequently the light showed irregular fluctuations, amounting to as much as two magnitudes in a single day.

In April the maxima and minima became more regular, with a period of from four to six days, and this continued until June, when the range of variation became less marked. By the middle of July the magnitude was about 6.5, at which it remained fairly constant for some time, ultimately fading gradually away.

When first discovered the *Nova* was white in color, but within a few days it became red, and so remained, with some modifications of tint at maxima and minima, until July. At this time, and subsequently, both in color (greenish) and spectrum, the *Nova* resembled a planetary nebula.

The changes in the spectrum were very remarkable, though in all respects typical of temporary stars. At first the spectrum was apparently continuous, but by February 24 broad and diffuse bright bands had appeared, accompanied on their violet sides by broad dark bands. The strength of the continuous spectrum, and the small degree of absorption in the dark bands, made the contrast very slight. It rapidly increased, however, as the photographs reproduced in Plate XXIII indicate. The bright hydrogen bands, which extended well out into the ultra-violet, were remarkably broad, averaging over 30 tenth-meters in width. The Lick Observatory measures of February 25 show the maxima of these bright bands to be displaced toward the violet about 8 tenth-meters from the normal positions of the hydrogen lines. By the middle of March they were displaced about 4 tenth-meters toward the red. The broad dark hydrogen bands, on the other hand, were displaced from 19 to 25 tenth-meters toward the violet. The dark H and K bands were similarly displaced about 16 tenth-meters, while the displacement of the dark D band was about 27 tenth-meters in the same direction. These shifts are corrected for radial velocity, which was easily measured with the aid of the narrow dark reversals of the bright H and K bands. These lines gave a practically constant mean value of about +6 km., and the narrow dark D reversals gave a velocity of the same order.

A discussion of the displacements of the *Nova* lines, based by Campbell and Wright[22] on their measures of the Mount Hamilton photographs, and by Becker[23] on measures of photographs made by himself at Glasgow, brings out the fact that the displacements of the lines are proportional to the wave-lengths, and independent of the particular elements to which they belong. The obvious bearing of this important conclusion on Wilsing's pressure theory will be mentioned later.

As the brightness of the *Nova* decreased the continuous spectrum faded, and the bright bands gained in contrast. The fluctuations in brightness, however, were reflected in the spectrum. A rise

[22] Lick Observatory *Bulletin*, No. 8.

[23] *Trans. Roy. Soc. Edinburgh*, Vol. XLI, Part II, No. 10.

to maximum was accompanied by a strengthening of the continuous spectrum relatively to the bright lines, but the latter regained their contrast on the approach to a minimum. These fluctuations continued for a time, but the gradual decline in the star's light resulted in a corresponding decrease in the intensity of the continuous spectrum and of the dark lines, while the bright lines became more prominent. During this time there were many changes in the relative intensities of the bright lines. K decreased greatly, and soon disappeared entirely. H doubtless shared a similar fate, but the broad *Hε* line prevented it from being observed. *Hβ* became narrower and sharper, and the relative intensities of its several components underwent marked variations. The dark bands on the more refrangible edge of the bright hydrogen lines, which were at first broad and poorly defined, changed about the middle of March to sharp double lines. Before they finally disappeared the duplicity vanished. The narrow dark D lines, and the bright band upon which they were projected, were of special interest. The bright band gradually moved toward the violet so that the two dark lines, which were at first nearly central on the band, were in April at its less refrangible edge. The dark line on the more refrangible edge of this band, nearly in the position of D_2, gave place to a much broader, but fainter, band extending toward the violet.

Spectroscopic observations of *Nova Persei* were interrupted during May and June, on account of its proximity to the Sun. When first observed by Pickering in July, the spectrum was found to be that of a nebula, the nebular lines being represented by broad bright bands. Certain anomalies in the *Nova's* spectrum, such as the abnormal brightness and altered position of a line near the place of *Hζ*, were explained by Wright's photographs of the spectra of nebulæ. A new nebular line was found which satisfactorily accounted for the *Nova* line. The narrow dark absorption lines at D and at H and K indicated no change in the radial velocity of the star. The broad bright bands, which contained many maxima and minima, were displaced from 8 to 13 tenth-meters toward the violet. Campbell and Wright[2] pointed out that these displacements were in all cases proportional to the wave-lengths of the bands. The principal bands showed a striking agreement with the known lines of the nebulae, and with bands observed in the spectrum of *Nova Aurigae*.

As already remarked, it is not our intention, in the present paper, to attempt a discussion of temporary stars or to deal with their general theory. The above brief outline of the principal spectroscopic phenomena of *Nova Persei* will suffice for our purpose, which is to point out the bearing of our experiments on Wilsing's pressure theory. We are unable to accept his theory, for the following reasons:

1. In the spectrum of the spark in liquids or compressed gases, the occurrence in the violet of pairs of bright and dark lines represents a condition of moderate pressure. When the pressure is increased (see Plate XXI), the bright lines widen and finally disappear, giving place to dark lines. At the high pressures supposed to exist in temporary stars, dark lines should appear on a continuous spectrum, rather than pairs of bright and dark lines, if a close analogy be assumed to exist between the stellar and the laboratory phenomena.

2. Our experiments, in harmony with theoretical considerations, show that selective absorption is a function of wave-length, and that line reversals begin in the ultra-violet, and advance toward the red with increasing pressure. If high pressure were a dominant factor in temporary stars, we should therefore expect to find a marked difference in the character of the reversals in different parts of the spectrum. Observations of *Nova Persei* and other temporary stars showed, however, a remarkable similarity of the hydrogen lines, from *Hα* in the red to the last recorded members of the series in the ultra-violet. In this connection it may be recalled that some of the Wolf-Rayet stars show the more refrangible hydrogen lines dark, while the less refrangible members of the series are only partially reversed or bright.

3. Pressure displacements in the laboratory are invariably toward the red end of the spectrum. The slight apparent shifts toward the violet of absorption lines in the spectrum of the spark in water

[2] *Loc. cit.*

are probably due to the presence of bright lines on their less refrangible side. Wilsing and Vogel have similarly explained the great displacements toward the violet of the dark bands in temporary stars, attributing them to the effect of overlapping bright bands.[25] Unfortunately, however, this explanation can account neither for the relative displacement of the dark bands after they were clearly separated from the bright bands,[26] nor for the displacement of the bright bands when photographed at the Lick Observatory on February 25, and again after the spectrum had become nebular.[27]

4. In Humphrey's investigations on the arc spectra of sodium and calcium, at a pressure of $10\frac{1}{2}$ atmospheres, the shifts for D (mean of D_1 and D_2), and for H and K, were as follows:[28]

	Δλ, observed	Δλ, reduced to λ 4000
D	119	81
H	25	25
K	22	22

As the shifts of these lines were found to increase in direct proportion to the pressure, the respective displacements of the D and the K lines in *Nova Persei*, when reduced to λ 4000, should be approximately in the ratio 81:22 if caused by pressure. It has been shown, however, that the displacements of these lines in the *Nova* were approximately equal, when reduced to the same wavelength. It is therefore impossible to see how the position or the character of the *Nova* lines could have been due to pressure.

It is not, of course, our intention to deny that differences of pressure existed in various parts of the mass of gases and vapors that constituted *Nova Persei*. We nevertheless conclude that the dominant features of the spectra of temporary stars are probably determined by some other cause, which we hope to investigate on a future occasion.

IV. SUMMARY

In the course of this investigation on the spectrum of the high potential discharge in liquids and compressed gases, undertaken for the purpose of testing Wilsing's pressure theory of temporary stars, the following results have been obtained:

1. Wilsing's observation that the spectrum of the iron spark in water contains compound lines, each consisting of a bright line on the less refrangible side of a dark line, is confirmed by our experiments.

2. By varying the self-induction in the discharge circuit of the condenser, the character of the spectrum can be greatly changed. With large self-induction, the spectrum of the spark between iron poles in water consists of bright lines, and resembles the spectrum of the iron spark in air. As the self-induction is decreased, dark lines begin to appear, nearly at the normal positions of the iron lines, while the bright lines are increasingly shifted toward the red and become more diffuse. With no self-induction, the bright lines almost entirely disappear, giving place to a spectrum of dark lines. These remarks apply especially to the region of the iron spectrum comprised between λ 3600 and λ 4500. It should be added, however, that with our apparatus some of the bright lines persist even when there is no self-induction in the discharge circuit.

3. An increase in the length of the auxiliary air spark; in the diameter of the water-spark terminals; in the diameter of the auxiliary air-spark terminals; in the capacity of the condenser; and perhaps in the temperature of the water: apparently tend to increase the absorption. The absorption is decreased by increasing the length of the spark in water and the self-induction in the discharge circuit; by the insertion in the discharge circuit of non-inductive resistance; and probably by other changes in the electrical conditions under which the discharge takes place.

[25] Vogel, "Ueber das Spectrum der *Nova Persei*," *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften*, Berlin, March 21, 1901.

[26] Sidgreaves, *Observatory*, May, 1901, p. 192.

[27] Lick Observatory *Bulletin*, No. 8.

[28] *Astrophysical Journal*, Vol. VI (1891), pp. 192 and 210.

4. In the spectrum of the spark in salt solutions the absorption seems to increase with the strength of the solution. This appears to be due, in large part, to a chemical effect, the presence of the salt producing a more rapid pulverization of the electrodes.

5. Manganese, antimony, bismuth, tin, gold, calcium, silver, nickel, cobalt, titanium, aluminium, lead, cadmium, and magnesium show absorption phenomena similar to those obtained with iron.

6. In an investigation of the positions of lines under different physical conditions, made with high dispersion, it was found that many of the causes stated above to be capable of changing the degree of absorption, at the same time produced displacements of the lines in the spectrum.

7. The passage of a high potential discharge is accompanied by the sudden production of a very high temperature and the liberation of a large quantity of metallic vapor. Both causes unite to bring about a sudden increase of pressure. The amount of metallic vapor produced in unit time, and consequently the effective pressure and degree of absorption, increases with the strength of the current and the difference of potential between the terminals. The decreased number of oscillations in the condenser discharge, caused by the insertion of self-induction, must tend to reduce this quantity, and consequently to diminish the absorption and the displacement of the lines. The effect of changing other conditions that determine the intensity and suddenness of the discharge may be accounted for on similar grounds.

8. In the case of lines in the same part of the spectrum, those of greatest intensity are usually the first to show evidences of reversal. In the case of lines of equal intensity (with some exceptions), those of shortest wave-length reverse first. The reversals advance toward the red end of the spectrum as the conditions become more favorable for increased absorption.

9. These reversal phenomena, in harmony with theoretical considerations, show that selective absorption, like general absorption, is a function of the wave-length.

10. In the spectrum of the spark between iron electrodes in compressed gases, it was found that pairs of bright and dark lines occur, similar to those obtained with the spark in water.

11. Reversal phenomena, similar to those obtained with the spark in water by varying the self-induction, were observed in gases as the pressure was increased.

12. At air pressures ranging from 1 to 20 atmospheres, the displacements of certain spark lines which are not reversed at these pressures, increase in direct proportion to the gauge pressure of the gas.

13. Certain dark lines, when reversed at low pressures, give pressure shifts which increase in direct proportion to the pressure, but usually at a less rapid rate than in the case of the bright lines.

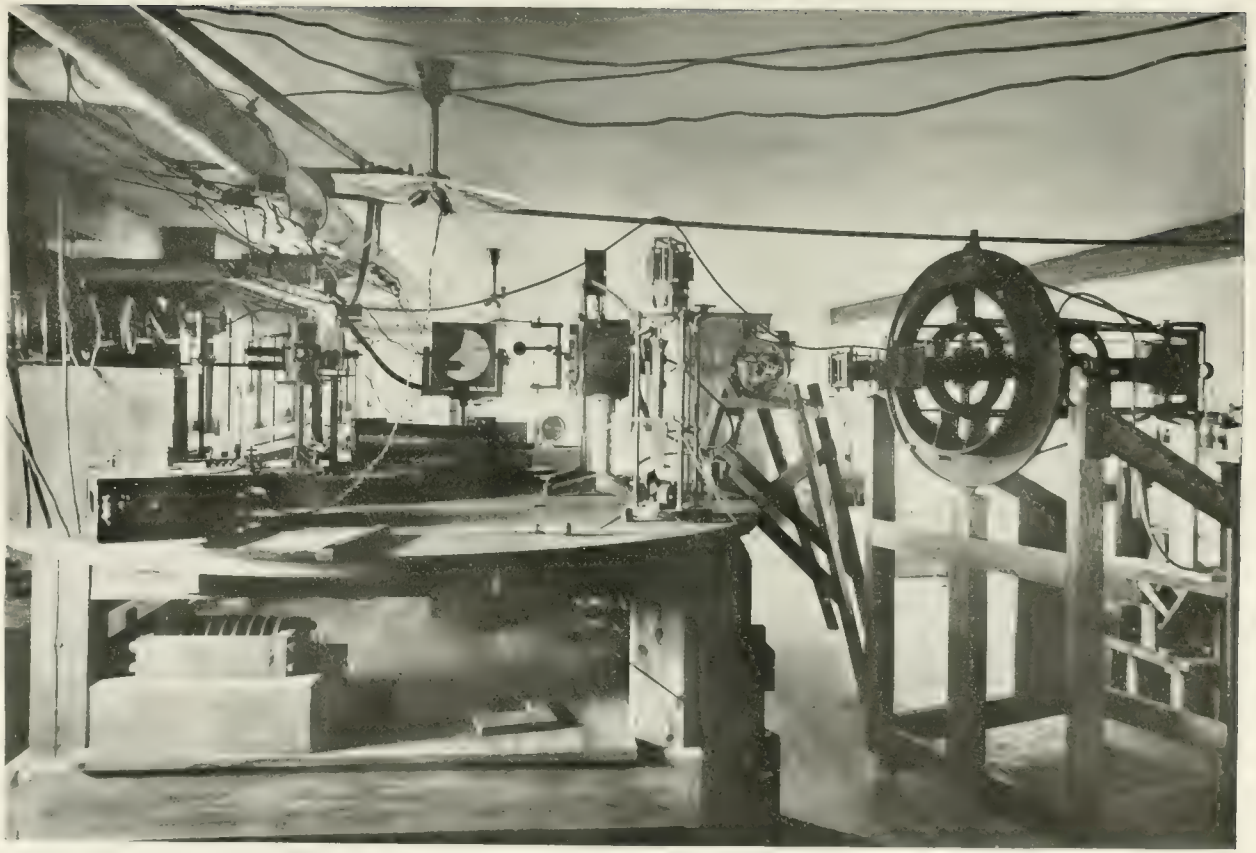
14. When a bright line is beginning to show signs of reversal, or when bright and dark lines occur in pairs, the observed pressure shifts are irregular, probably because the overlapping lines prevent settings from being made on their true centers.

15. In comparing our pressure displacements with those of Humphreys (Plate XXII), it will be noted that in the case of several lines our displacements are larger for the same gauge pressure.

16. Our conclusions as to the bearing of the above results on Wilsing's pressure theory of temporary stars are given on p. 64.

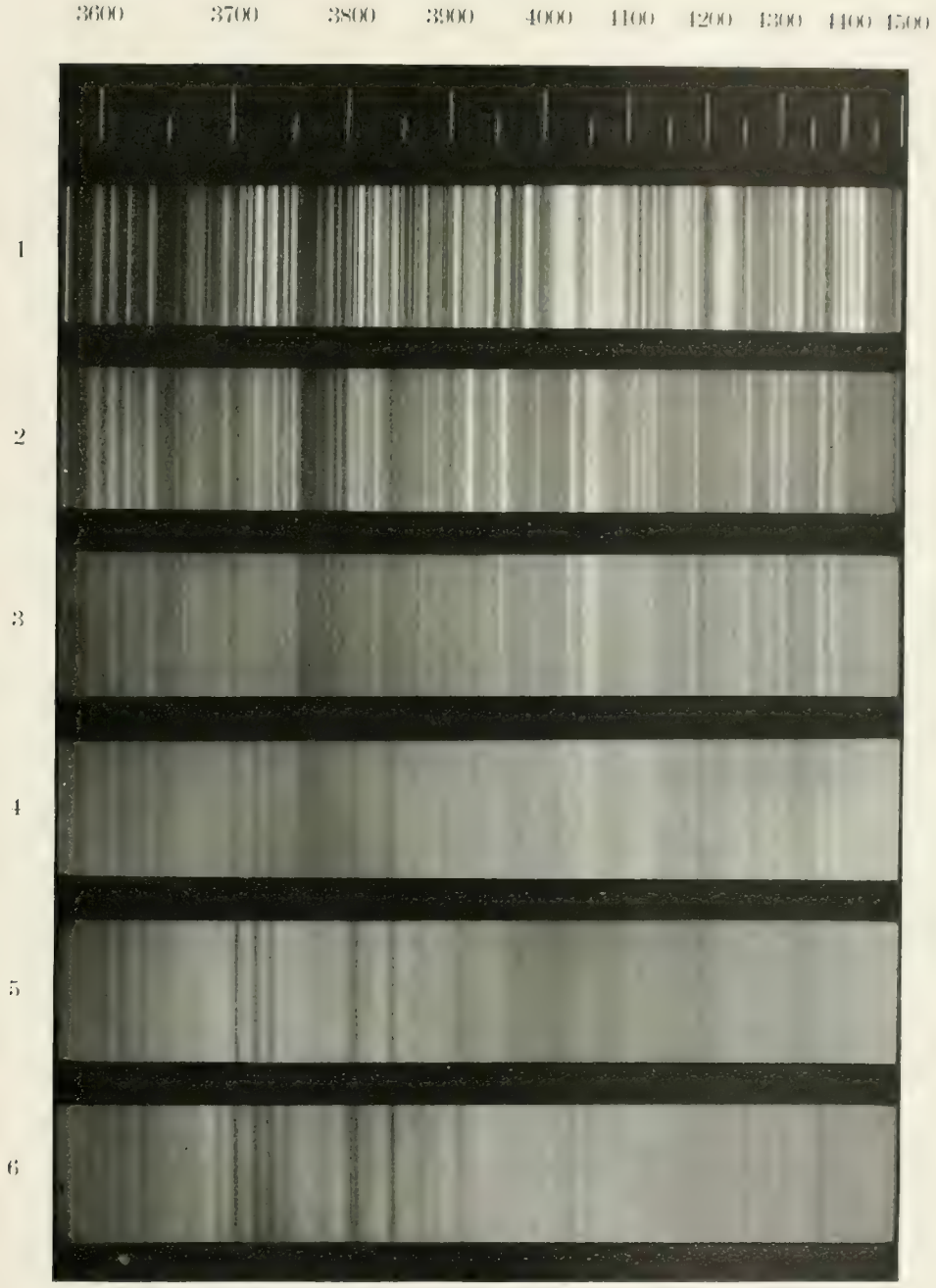
We wish to express our thanks to Mr. Ellerman and to Mr. Hartley, for making the enlargments of our photographs which are reproduced in the Plates.

PLATE XVI



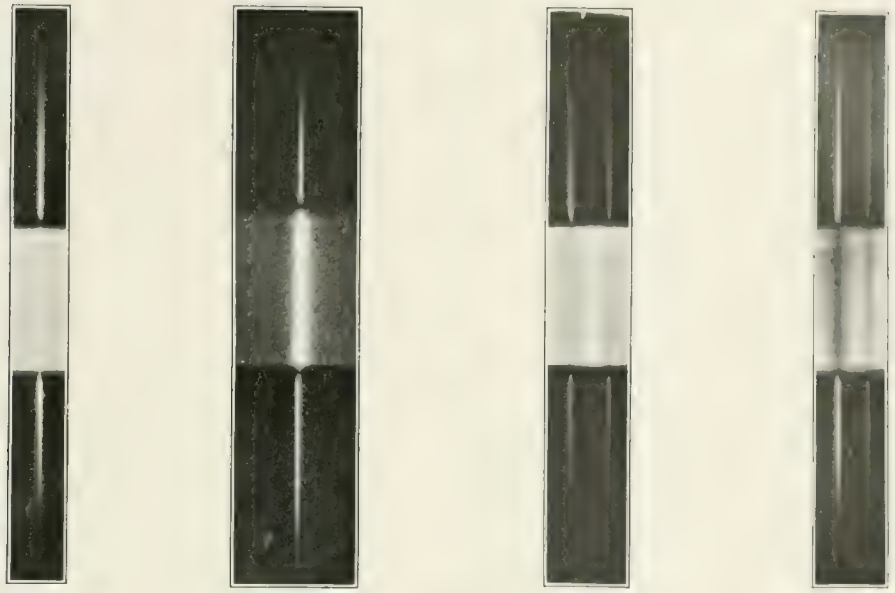
CIRCULAR TABLE, SHOWING APPARATUS FOR SPARK IN LIQUIDS AND COMPRESSED GASES

PLATE XVII

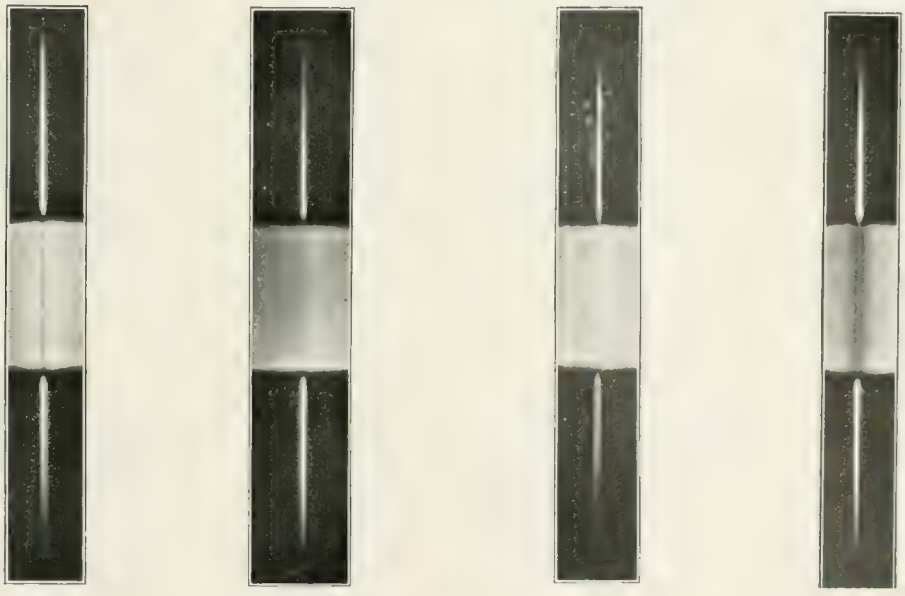


THE SPARK SPECTRUM OF IRON IN AIR (1), IN WATER (2, 3, 4), AND IN SODIUM CHLORIDE SOLUTIONS (5, 6)

PLATE XVIII



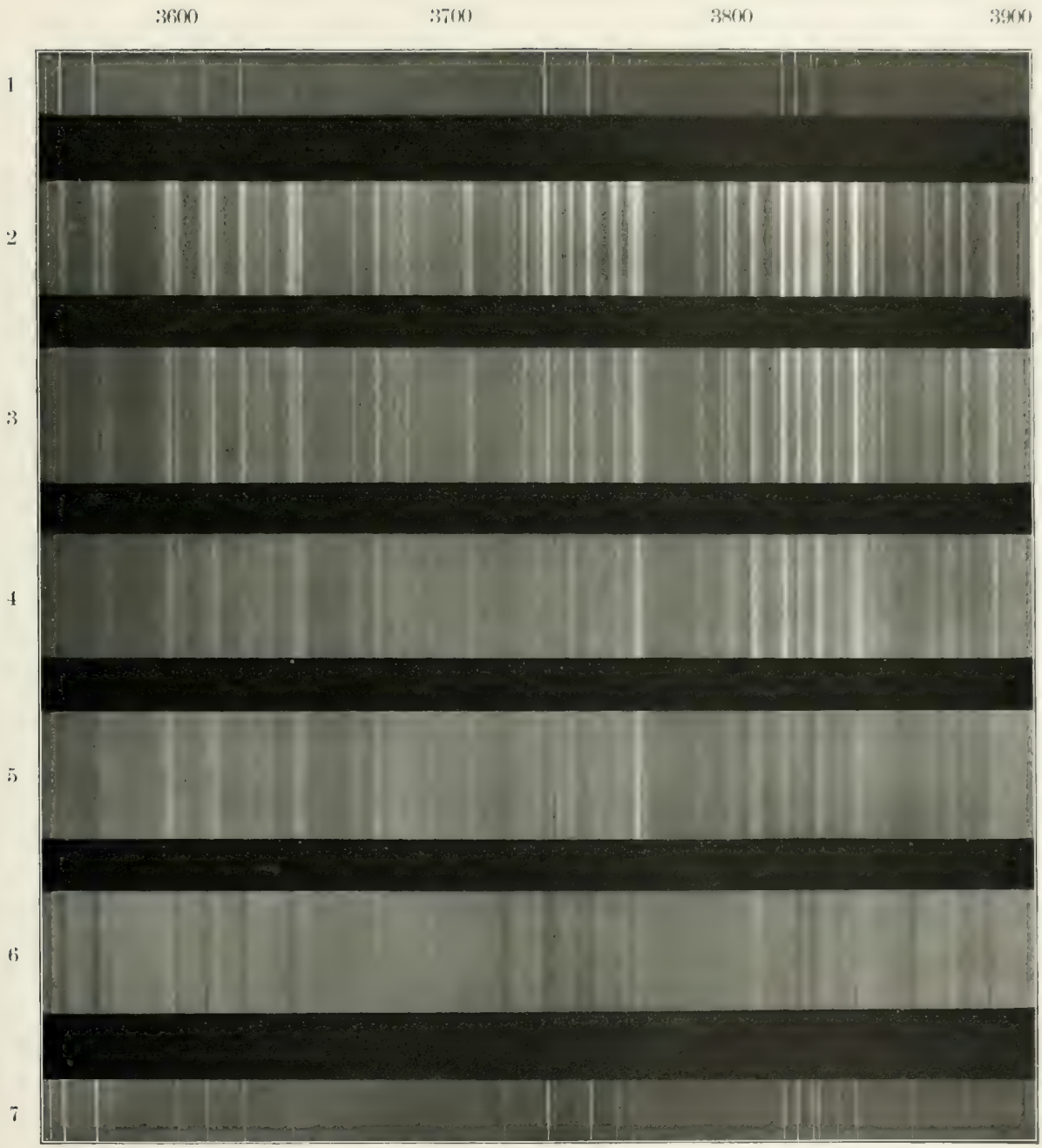
1 2 3 4



5 6 7 8

TYPES OF LINES IN THE SPECTRUM OF THE IRON SPARK IN WATER

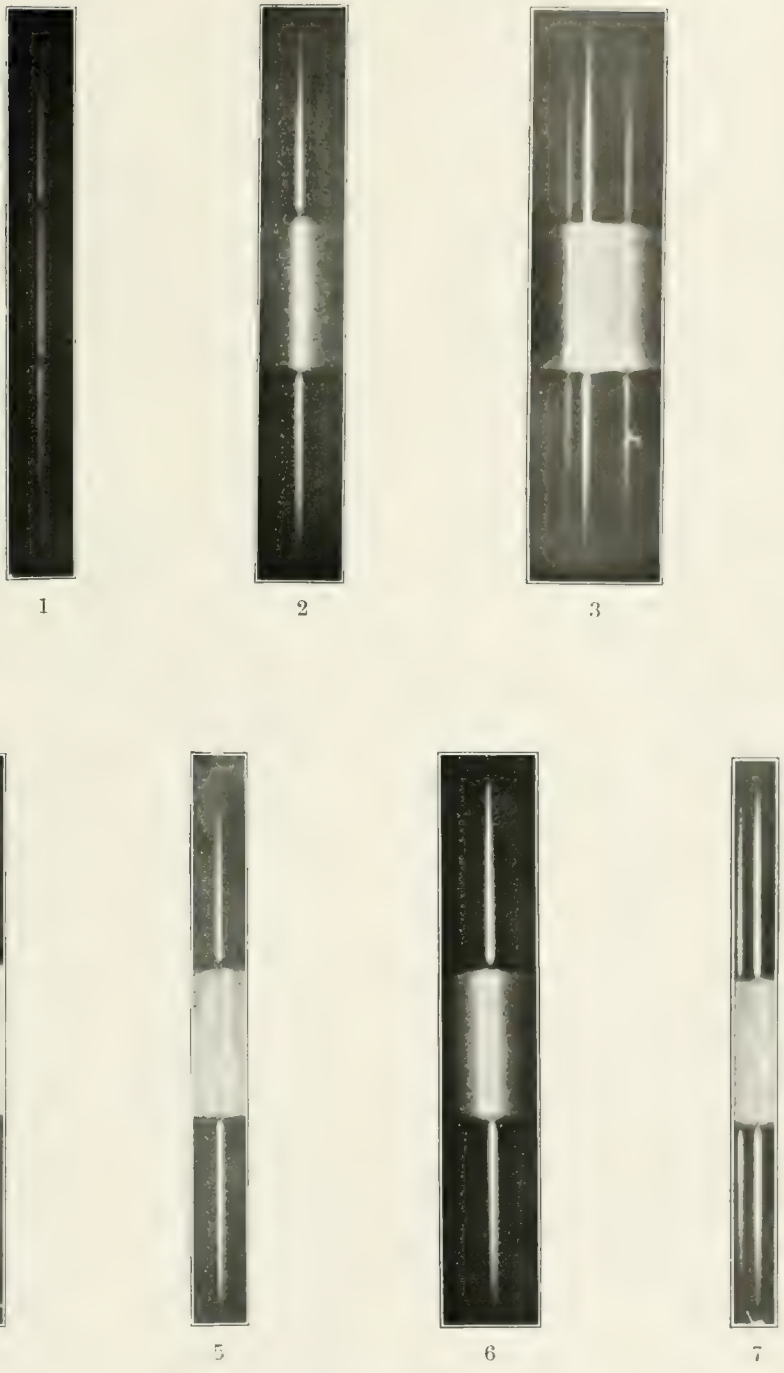
PLATE XIX



EFFECT OF SELF-INDUCTION ON THE SPARK SPECTRUM OF IRON IN WATER

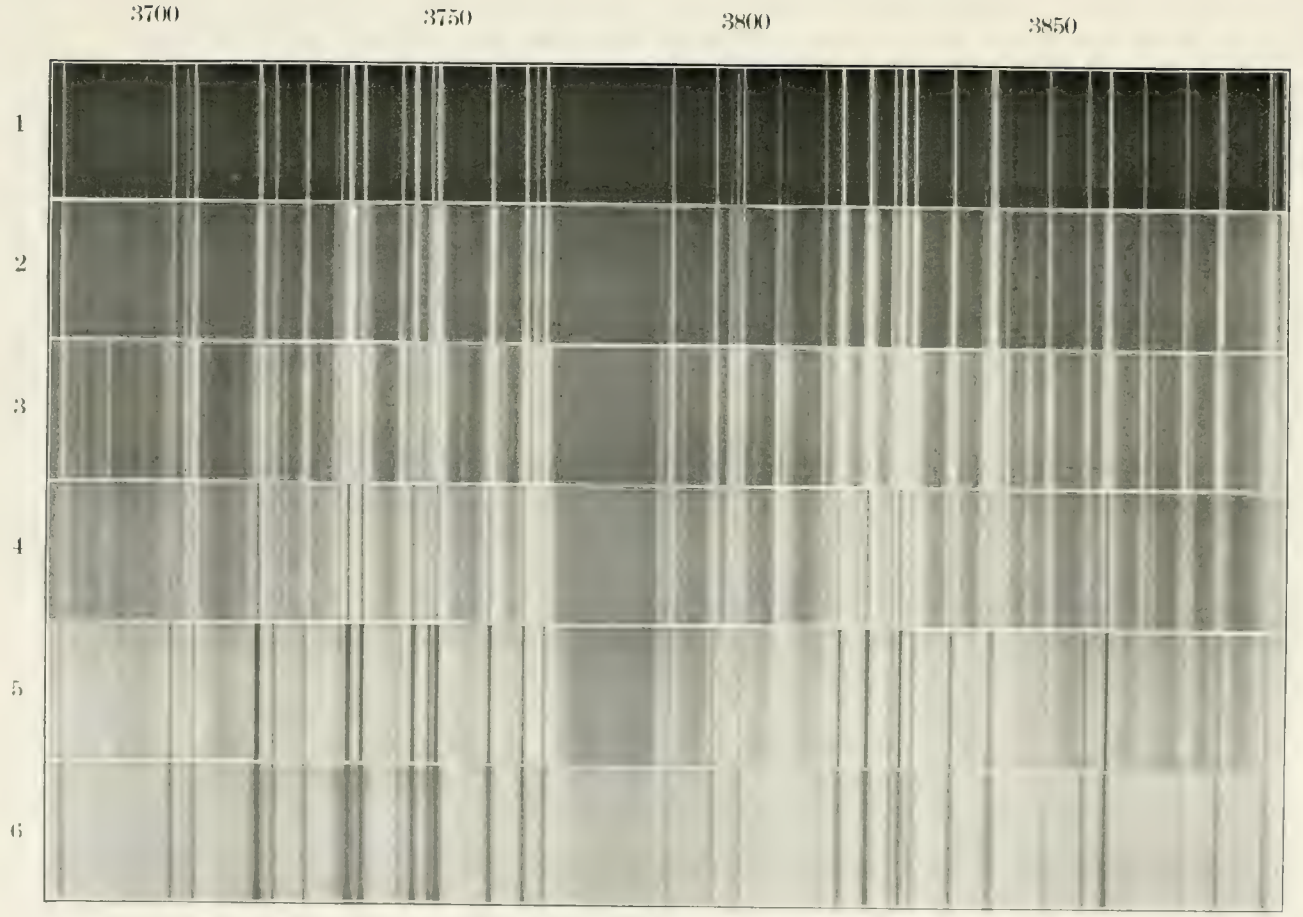
1 and 7. Spark in air at atmospheric pressure.
2 to 6. Spark in water, showing changes caused by increasing self-induction.

PLATE XX



TYPES OF LINES IN THE SPECTRUM OF THE IRON SPARK
IN COMPRESSED GASES

PLATE XXI



THE SPARK SPECTRUM OF IRON IN COMPRESSED GASES

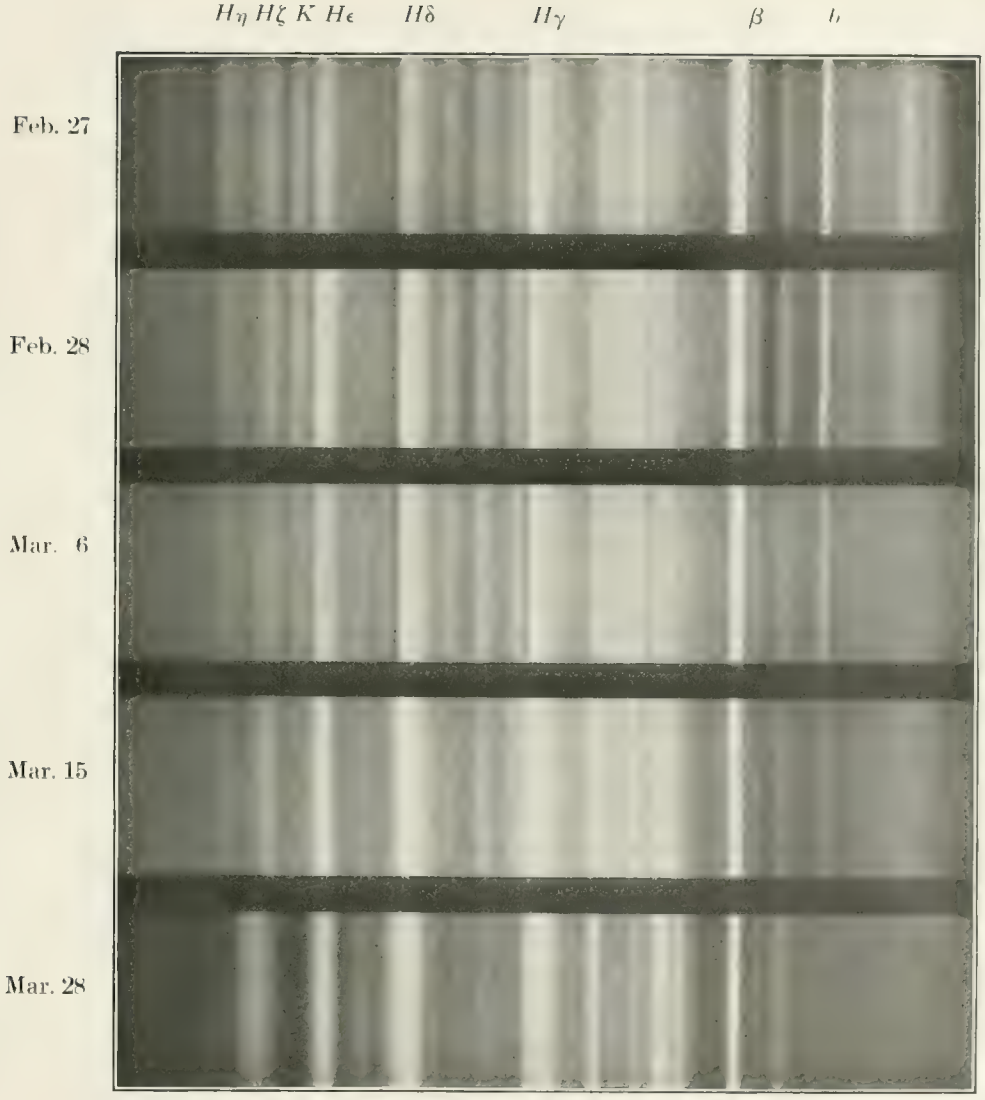
1. In air at atmospheric pressure.
2. In air at 3.3 atmospheres.
3. In air at 7.3 atmospheres.
4. In air at 11 atmospheres.
5. In CO at 27.3 atmospheres.
6. In CO at 53.3 atmospheres.

PLATE XXII

DISPLACEMENTS OF IRON LINES IN COMPRESSED AIR

Ordinates are Displacements, in hundredths of a tenth-meter. Abscissae are Pressures in Atmospheres. Humphrey's values are indicated thus +.

PLATE XXIII



SPECTRUM OF *NOVA PERSEI*

Photographed with the 40-inch Yerkes Telescope by Ferdinand Ellerman

THE ROTATION PERIOD OF THE SUN

as Determined from Measures of Plates
Taken with the Rumford Spectroheliograph

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PUBLICATIONS OF THE YERKES OBSERVATORY

VOL. III PART III

THE ROTATION PERIOD OF THE SUN

as Determined from Measures of Plates
Taken with the Rumford Spectroheliograph

BY
PHILIP FOX

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INTRODUCTORY NOTE

By Edwin B. Frost, Director

The issue of this memoir as Part III of Volume III involves a change from the original plan in respect to this volume, for it had been intended that Part III should be the extensive memoir on his micrometric measurements of stars in the globular clusters by Professor Edward E. Barnard. Part I (pages 1–26), "The Rumford Spectroheliograph of the Yerkes Observatory," by George E. Hale and Ferdinand Ellerman, was printed in 1903. Part II (pages 29–66), "The Spectrum of the High Potential Discharge between Metallic Electrodes in Liquids and in Gases at High Pressures," by George E. Hale and Norton A. Kent, was printed in 1907. The sheets of these parts were not bound up, at the time, as it was intended to issue them in the completed volume; they were distributed as separate parts only recently. Because of the necessity of extending for a longer term of years the measures of the clusters by Professor Barnard, that work, when completed, will appear in some future volume.

The present paper by Professor Fox, of Northwestern University, Director of the Dearborn Observatory, is based upon observations made by him with the Rumford spectroheliograph during the period while he was a member of the staff of the Yerkes Observatory, 1903–1905 and 1906–1909. Many of the measurements on the globe measuring machine were made by Mr. Fox on occasional visits to this observatory in 1912 and in 1913. The results of the work in nearly final form were communicated to the American Astronomical Society by him at the meeting in the summer of 1914. The military service of Major Fox then deferred for several years the final revision of the manuscript.

The fourth and concluding part of the present volume will be the paper on "The Forms and Motions of the Solar Prominences" by Edison Pettit (Thesis for the degree of Doctor of Philosophy in the University of Chicago, August, 1920). It is hoped that this can be issued before the end of 1921.

Yerkes Observatory
July 1921

ROTATION OF THE SUN

By Philip Fox

INTRODUCTION

A selected number of plates from the series of spectroheliograms made at the Kenwood Observatory in 1892–94 were measured in 1903–4 and gave the first results on the rotation period of the Sun from the motion of calcium flocculi in heliographic longitude.[1] Before the results were published the Rumford spectroheliograph at the Yerkes Observatory had been put into successful operation and also the spectroheliograph of the Mount Wilson Observatory. It was therefore possible to write:[2] "We are both engaged in work with powerful instruments, which furnish larger solar photographs, much richer in detail and better suited for measurement than the Kenwood plates. We accordingly expect to return to this discussion with the advantage afforded by a longer series of better observations." The present paper, long delayed in publication, is the fulfilment of this expectation so far as the series of plates with the Rumford spectroheliograph is concerned. That this work was in progress has been evidenced by various references to it and by some preliminary reports.[3]

RUMFORD SPECTROHELIOGRAPH

The Rumford Spectroheliograph has been fully described by Hale and Ellerman in Vol. III, Part I, of these publications. In that place and in numerous subsequent papers by Fox, Abetti, Slocum, Lee, and Pettit, the character of the plates made with the instrument has been illustrated. For the purpose of measurement, the large solar image (diameter = 178 mm), with consequent finer definition, offers obvious advantages over the smaller image (diameter = 51 mm) of the Kenwood plates used in the earlier investigation. Moreover, the distortion of the image found in the Kenwood spectroheliograms, due to the curvature of spectrum lines, was very cleverly avoided in the Rumford spectroheliograms.[4] If the instrument is in perfect adjustment and properly mounted on the telescope, the images are circular and free from distortion.

In the long series of adjustments[5] necessary in this complex instrument some, unfortunately, were not sufficiently discriminative and some were difficult of maintenance or not scrupulously observed, so that many of the early plates and, for certain periods, some of the later ones do not have circular images.

The whole series from 1903 to 1908, inclusive, was very carefully examined for suitability for measurement. The best plate of each day of a succession of two or more clear days was chosen. In all, 285 plates have been measured. They were made by the following observers:

Fox	188	Fox and S. A. Mitchell	1
Fox and Abetti	57	Ellerman	13
Fox and Slocum	19	Slocum	2
Fox and Brown	4	Abetti	1

Prints were made from the negatives and these were carefully compared. Features in the flocculi which persisted from day to day were marked on the prints for measurement. The character of these

[1] Hale and Fox, *The Rotation of the Sun*. Carnegie Institution of Washington, Publication No. 93, 1908.

[2] *Ibid.*, p. 53.

[3] *Transactions of the International Union for Solar Research*, Vol. II (1908), pp. 192, 194, and Vol. III (1911), p. 97. *Science*, N.S., Vol. XXV (1907), p. 613. *Publications of the American Astronomical Society*, Vol. III (1918), p. 80.

[4] *Publications of the Yerkes Observatory*, Vol. III (1903), p. 7.

[5] *Ibid.*, Vol. III (1903), p. 12.

points is shown on the marked print of Plate XXIV. Their persistency may be seen by careful comparison of the photographs in Plate XXV. Some of the flocculi changed form very rapidly, so that the points in many cases could not be followed with certainty for more than a day even though plates were available for a longer period.

METHOD OF MEASUREMENT AND COMPUTATION

The globe measuring machine used for the Kenwood spectroheliograms was employed. It was, however, altered in certain important respects in the midst of the series. This instrument, as originally used, was described in the earlier paper, but inasmuch as that paper is not generally accessible the essentials of the description are repeated here.

The photographs were projected by means of the light from an electric arc lamp upon a globe accurately ruled with a series of meridians and parallels, Plate XXVI. The parts of the apparatus in its first form were: (*a*) an arc lamp, self-feeding, so as to keep the arc at a fixed point; (*b*) a condensing lens, 10 inches

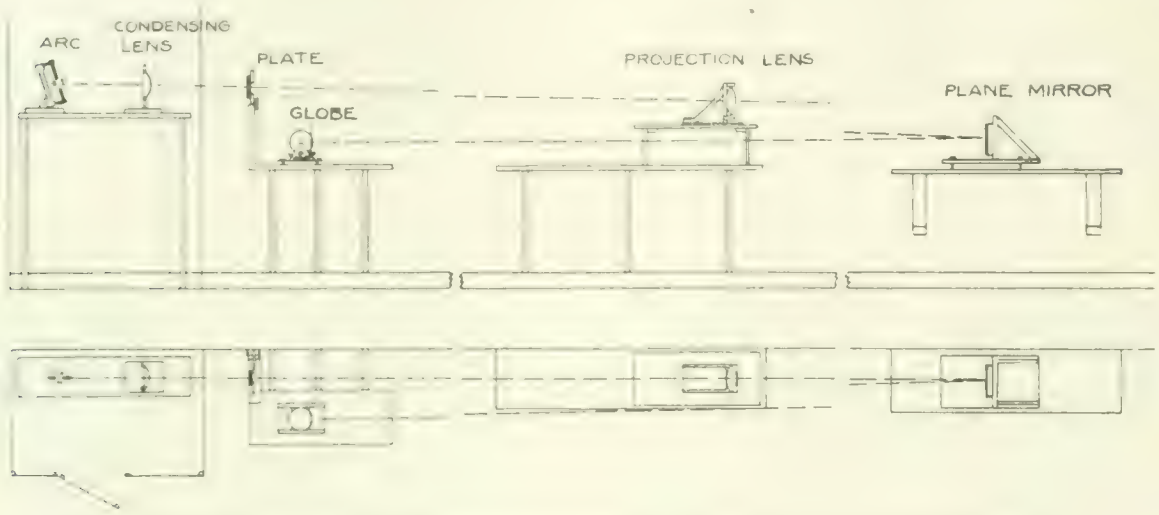


FIG. 1.—Arrangement of the measuring apparatus in its original form: elevation and plan

(25.4 cm) in diameter; (*c*) a frame to carry the solar plate, Figure 2; (*d*) a projection lens,—the lens used was a 12-inch (30.5 cm) objective of 18 feet (5.49 m) focal length, so placed that it formed the image of the photograph on the globe; (*e*) a plane mirror inserted in the path of the rays to secure the necessary distance of the globe from the lens in the limited space available; (*f*) a globe of diameter 9.53 inches (24.21 cm), on which was accurately ruled a set of meridians and parallels of latitude. The arrangement of the apparatus in the original form is shown in Figure 1.

To [illegible] the process of projecting a photograph on this globe amounts to throwing it upon an artificial sun provided with a visible net of meridians and parallels for the measurement of heliographic longitudes and latitudes. The primary requirements are: (*a*) that the globe should be at such distance, 26.0 m, from the projection lens that it would subtend an angle equal to the solar diameter; (*b*) that the equation, $\frac{1}{a}+\frac{1}{b}=\frac{1}{f}$, should be fulfilled, where a, b, and f are respectively the distance of the plate from the lens, the distance of the globe from the lens, and the focal-length of the lens; (*c*) that the size of the solar [illegible] on the plate should be [illegible] to [illegible]. To fulfil these relations lantern slides were made from the original plates to give a solar diameter of 2.55 inches (6.48 cm).

The first 121 plates of this series were measured under these conditions. Thereafter a concave mirror, made by Mr. O. L. Petitdidier, was substituted for the lens and plane mirror. Its aperture was

8.5 inches (21.6 cm) and the focal-length such that the plate and globe could be in the conjugate foci and at the same time permit the use of the original negatives which have solar images of 7.0 inches (17.78 cm) diameter. The focal-length was 36.1 feet (11.0 m). In this form the instrument was used as a Herschellian reflector, Figure 3. Needless to say, the plate and the globe were put as near the optical axis as was possible without interference. This form of the instrument was simpler and more satisfactory in use.

The orientation for position angle of the sun's axis was accomplished by rotating the plates on the frame (*c*) about the axis of projection, and for heliographic latitude of the center of the disk by rotating the globe about a horizontal axis perpendicular to the axis of projection. The image was centered concentrically on the globe in the first form of the apparatus by moving the frame (*c*) which held the plate

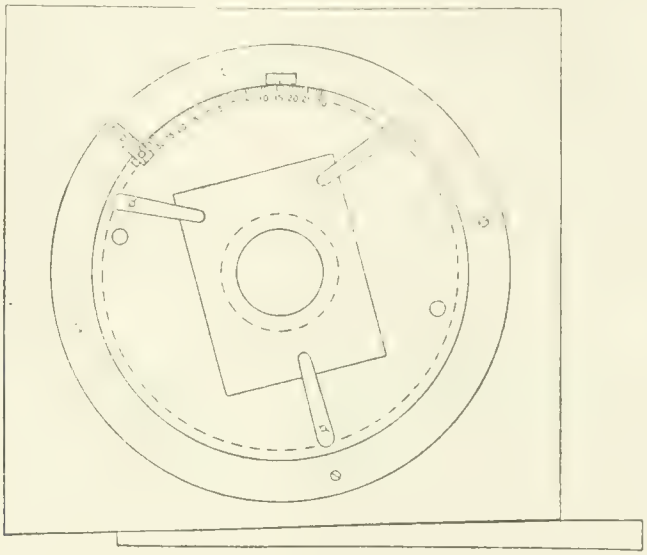


FIG. 2.—Plate-holder of the globe measuring machine

FIG. 3.—Arrangement of the measuring apparatus in its modified form

right and left and by means of a double wedge up and down. The frame was beside the globe and the adjustment could be made without moving from the globe. In the second form the centering was accomplished by rotating the mirror about two axes, one vertical and one horizontal. Cords were run from the mirror to the globe so that the movements about these axes could be accomplished by the observer without moving from the globe. As it was not planned to measure the positions of flocculi near the limb of the Sun, and as it was difficult to tell when the image was accurately centered on the globe by direct observation, a screen was mounted in front of the center of the globe through which the face of the globe toward the plate projected. (See Plate XXVI.) On this screen a circle was ruled concentric with the periphery of the globe as seen from the plate. When the image was brought to fit this circle it was adjusted both in size and position. The globe could be moved to and from the lens through a limited range so that its angular diameter as seen from the projection lens would correspond to the varying angular diameter of the Sun itself in the sky.

MEASUREMENT

The circles on the globe were at intervals of degrees, and positions of all points were estimated to one-tenth of a degree. Few points were measured which were more than 45° from the central meridian, for any displacement of the image as a whole would be magnified in heliographic position as the limb was approached. With the instrument in careful adjustment and the plate properly oriented, the measurement of positions was accurate to about one-tenth of a degree. The positions of sun-spots were also measured and will be found with a discussion in Addendum II.

The process of measurement was greatly facilitated and accelerated by previously selecting the points to be measured from the prints and listing them in order in the notebook. The time required at the measuring machine for a plate varied from one to two hours, depending on the number of points measured. All measures of position are collected in Table I, where the different columns contain the plate number and date, the number of the point, the latitude, the diurnal sidereal motion, the diurnal synodic motion, and the longitudes from the central meridian on the first, second, third, etc., days. All observations

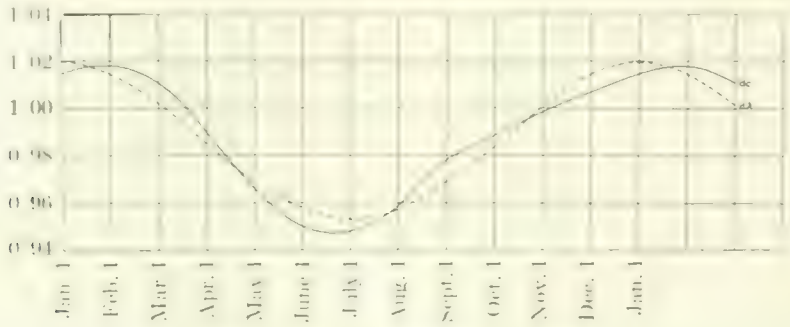


FIG. 4.—Curves for the transformation of synodic diurnal motions to sidereal diurnal motions

of any point are found under the date of first appearance. The longitudes in Table I for the second, third, etc., day belong to plates which successively follow in the table. The latitude given is the mean of the observations of the several days. The diurnal synodic motion (x) in longitude was derived for each point by a least-square solution, the general formula[6] being

$$x = 1440\,\frac{K[t\gamma] - [t][\gamma]}{K[t^2] - [t]^2},$$

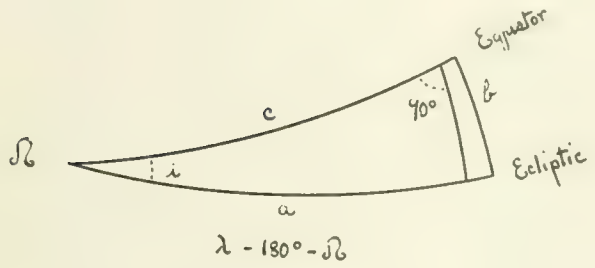
where t is the time in minutes from the date of the first plate to that of the subsequent individual plates, γ is the difference in longitude of the individual plates taken from the first plate, and K is the number of observations.

The individual longitudes are given with reference to the central solar meridian as seen from the Earth. This is not a fixed reference circle but is moving due to the orbital motion of the Earth, and the diurnal motions derived from the measures of course are the synodic diurnal motions. The motion of the Earth is named in the American *Ephemeris* as a change in the longitude of the Sun. It is not constant; but, for any [illegible] measured on from two to six days we can safely assume that it is constant since the treatment of the measures is purely differential. The daily value of the Earth's motion we will call $\delta\lambda$. As the Sun's [illegible] in the ecliptic we have a varying component of the $\delta\lambda$ affecting the motion

[6] [illegible]

of the central meridian. The value of $\delta\lambda$ has been platted for the different days of the year as a broken line in Figure 4. To evaluate the projection of this on the solar equator the following solution is given:

$$\begin{aligned} \cos a &= \cos b \cos c \\ \sin a \cos i &= \cos b \sin c \\ \tan a \cos i &= \tan c \end{aligned} \qquad (1)$$



Differentiating:

$$\cos i \sec^2 a \, \delta a = \sec^2 c \, \delta c \qquad (2)$$

from which, putting $\delta a = \delta\lambda$

$$\frac{\tan c}{\tan a} = \frac{\cos^2 a \, \delta c}{\cos^2 c \, \delta\lambda}$$

whence,

$$\delta c = \frac{\sin 2c}{\sin 2a} \delta\lambda \qquad (3)$$

In these equations $i = 7°15'$, $a = \lambda - 180° - \Omega$ = the heliocentric longitude of the Earth from the ascending node of the Sun's equator. The value of δc was determined for various dates through the year and is platted as the continuous line in Figure 4. The addition of the diurnal value of δc to the diurnal synodic motion gives at once the diurnal sidereal motion.

TABLE I

OBSERVATIONS AND DIURNAL MOTIONS

PLATE NUMBER AND DATE	NUMBER	LATITUDE	DIURNAL MOTIONS		LONGITUDES IN DAYS OF OBSERVATION						
			Sidereal	Synodic	1	2	1	4	5	6	7
449	37	−17°.5	14 48	13°.52	27 5	38°.1					
Aug. 6, '03	38	−23 0	14 99	14.03	22 9	33 9					
1.50^h	39	−18 0	14.86	13 90	15.0	25 9					
C S T ^a	40	12 8	15.24	14 28	10 0	21 2					
	41	13 2	15.24	14 28	7.9	19 1					
	42	15 5	14 73	13 77	6 7	17.5					
	43	15 4	13.84	12 88	− 0 4	9.7					
	44	19 2	14 22	13.26	− 2 2	8.2					
	45	23 5	14 35	13 39	4 9	5 6					
	46	27.3	13 81	12 88	− 2 0	8.1					
	47	20.0	14.73	13 77	− 9 .	1 5					
	48	15 9	14.22	13 26	− 9 9	0 5					
	49	22.3	14 22	13 26	− 13 9	− 3.5					
	50	−23.8	14.73	13.77	−41.7	−30.9					
	51	−25.0	14 48	13.52	−40.9	−30.3					
	52	−21.9	13 20	12.24	−39 4	−29 8					
	53	19 9	14.22	13 26	−12 4	− 2.0					
	54	26 0	14.73	13.77	− 7.8	3.0					
	55	27.5	14.99	14 03	−10 4	0.6					
	56	18.5	15.24	14.28	20.0	31.2					
452	...	...	...	...							
Aug. 7, '03											
8.39^h											
480	57	−22 2	14 89	13 92	23 5	34 5					
Aug. 17, '03	58	14 9	15.14	14.17	28 8	40 0					
3.10^h	59	17.6	14.89	13 92	32.0	43 0					
	60	18 6	14.89	13 92	34.1	45.1					
	61	19 3	14.76	13 79	28.2	39.1					
	62	21.9	13.88	12.91	28.0	38.2					
	63	24 0	13.37	12 40	28 9	38.7					
	64	25 2	13.88	12 91	31.8	42 0					
	65	23 4	14 13	13.16	26 9	37 3					
	66	20 9	14 64	13 67	20 2	31.0					
	67	26 8	13 46	12.49	21 8	31.5	47°0				
	68	24 3	13.74	12 77	18 0	28.1					
	69	16 3	14 69	13 72	16 3	27.1	44 0				
	70	15 9	14 26	13 29	12.7	23 2					
	71	−20 2	15.14	14 17	2 9	14.1					
	72	−21 3	14 58	13 61	− 2.1	8.8	25 4				
	73	−25 1	14 62	13 65	− 2 6	8.5	25 0				
	74	22 2	13 74	12.77	− 0.1	10 0					
	75	24 0	13 62	12 65	− 0 9	9.1					
	76	32 4	13.24	12 27	− 5 8	3.9					
	77	28 5	13 48	12 51	− 7.6	2 0	16 3	30 0	39°9		
	80	−27 6	13.77	12 80	18 3	28 0	44.1				
	81	−29 9	14 38	13 41	21 2	31 8					
	82	−28 9	14 00	13 03	23 9	34.2					
	83	−19 9	14 89	13 92	8.8	19 8					
	84	−19 9	15 02	14 [illegible]	9 8	20 9					
	85	−17 2	15 02	14 [illegible]	− . .	7 8					
	86	−17 5	14 33	13 [illegible]	− 7 8	2 9	19 2				
	87	27 6	13 37	12 40	[illegible] 4	26 2					
	88	24 2	13 [illegible]	12 96	9 1	19.5	35 3				
	89	20 5	13 89	12 92	10 5	20 1	36 5				
	90	24 8	13 24	12 27	−36 4	−26 7					
48[illegible]	78	19 4	14 15	13 18	24 3	40 3					
Aug. 18, '03	79	−20 0	14 40	13 43	10 6	36 9					
[illegible]	91	30 9	12 50	11 53	- 33 0	−19 0					
	92	29 1	13 [illegible]	12 53	- 36 9	−21 9	− 8 7	0 5			
	93	28 4	13 70	12 [illegible]	[illegible]0	- 23 7	−10 5	− 1 0			
	94	30 3	13 80	12 83	[illegible]	- 29 1	15 0	− 5.7			
	95	32 3	14 16	13 [illegible]	[illegible]0	−32 4	−18 9	− 2 1			
	96	4 4	14 19	13 22	- 52 7	- 36 0	−22 9	−16 9			

[illegible]

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
485 (*cont.*)	97	− 3°.9	14°.13	13°.16	−54°.3	−37°.9	−24°.5	−14°.9			
	98	12.1	14.55	13.58	−22.3	− 5.8	8.2				
	80	−17.5	14.34	13.37	10.9	27.3	40.9				
494	99	22.1	14.61	13.64	−10.6	3.5	13.5				
Aug. 19, '03	100	23.2	14.78	13.81	−13.2	1.0	11.2				
3^h38^m	101	25.0	14.21	13.24	−15.6	− 2.0	7.8				
	102	31.7	14.48	13.51	−24.8	−11.2	− 0.9				
	103	27.3	13.94	12.97	−29.3	−15.7	− 6.4				
	104	26.2	13.92	12.95	−31.0	−17.8	− 8.1				
	105	30.8	14.53	13.56	6.7	20.3	30.7				
	106	34.6	14.16	13.19	13.7	27.3	37.0				
	126	27.6	13.74	12.77	−31.5	−18.7	− 8.9				
502	107	26.6	13.58	12.61	− 3.6	5.9					
Aug. 20, '03	109	22.6	14.38	13.41	−15.8	− 5.7					
4^h00^m	110	20.1	14.11	13.14	4.4	14.3					
	111	−27.7	14.64	13.67	−22.3	−12.0					
	112	−27.2	14.77	13.80	−27.4	−17.0					
	113	−31.2	14.77	13.80	−31.7	−21.3					
	114	−24.0	14.24	13.27	13.9	23.9					
	115	−27.3	14.64	13.67	15.9	26.2					
	116	−29.2	13.98	13.01	15.1	24.9					
	117	−33.5	13.31	12.34	17.0	26.3					
	118	23.0	14.51	13.54	33.6	43.8					
	120	17.1	15.17	14.20	38.5	49.2					
	121	36.9	13.18	12.21	14.9	24.1					
	122	35.4	13.71	12.74	11.2	20.8					
	123	25.5	13.58	12.61	−11.5	− 2.0					
	124	22.5	13.58	12.61	− 9.2	0.3					
	125	38.5	15.17	14.20	9.0	19.7					
503											
Aug. 21, '03											
10^h05^m											
516	127	−26.2	14.12	13.14	12.2	22.0	35.0				
Sept. 10, '03	128	−30.0	13.26	12.28	−10.2	− 1.0	11.1				
4^h20^m	129	−31.5	13.96	12.98	6.2	16.1					
	130	−28.2	13.83	12.85	5.3	15.0	27.6				
	131	20.3	14.42	13.44	−16.5	− 6.7	6.8				
	132	19.1	14.40	13.42	−13.3	− 3.1	10.0				
	133	22.1	13.76	12.78	−12.2	− 2.4	10.0				
	134	24.0	14.65	13.67	−21.5	−10.3	2.3				
	135	24.5	14.36	13.38	−18.4	− 8.2					
	136	20.7	14.34	13.36	−25.5	−15.2	− 2.3				
	137	20.8	14.10	13.12	−27.9	−17.7	− 5.1				
	138	19.9	14.11	13.13	−31.3	−21.3	− 8.5				
	139	23.1	14.09	13.11	−27.9	−17.9					
	140	23.1	13.82	12.84	−29.5	−19.5	− 7.2				
	141	27.8	14.23	13.25	−28.0	−17.9					
	142	27.3	14.24	13.26	−25.0	−15.1	− 2.0				
	143	14.6	14.69	13.71	−20.8	−10.4	3.0				
	144	8.1	15.28	14.30	−36.9	−26.0					
	145	19.3	13.36	12.38	−35.0	−25.4	−13.5				
	146	27.9	13.90	12.92	− 7.8	1.7	14.6				
	147	26.5	14.79	13.81	− 5.0	5.8	19.0				
	148	26.2	14.46	13.48	− 3.1	7.1	20.3				
	149	23.2	14.43	13.45	− 4.2	5.5	19.1				
	150	22.1	13.83	12.85	− 2.8	7.0					
	151	20.3	13.83	12.85	0.0	9.7	22.3				
	152	21.6	13.82	12.84	0.8	10.8	23.1				
	153	18.7	14.23	13.25	0.2	10.2	23.2				
	154	15.6	14.30	13.32	− 2.4	7.5	20.7				
	155	17.2	14.34	13.36	9.6	19.8	32.8				
	156	17.7	13.93	12.95	8.4	18.5	30.9				
	157	22.9	14.36	13.38	10.0	20.2					
	158	22.4	14.81	13.83	7.5	17.9	31.5				

TABLE 1 (*Continued*)

Plate Number and Date	Number	Longitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
516	159	25°6	14°06	13°08	5°9	15°8	28.6				
	160	22 6	14.75	13 77	13 0	23.5					
	161	18 3	14.33	13.35	21.5	32.0	44.7				
	162	19.8	14.62	13.64	24 8	35.2					
	163	17.0	13.70	12.72	34.5	44.2					
	164	1 3	13 57	12 59	15 9	25.5					
	165	10 4	14.88	13 90	19.1	29.7					
	166	29 7	12 78	11.80	3 5	12.5					
	167	14 0	13 96	12.98	−12.2	− 2.3					
	168	17.2	14 85	13.87	−28.1	−17.2	− 4.0				
	169	22 8	13 57	12.59	−23.2	−13.6					
	170	−28 6	13 38	12.40	8.5	17.5	30.0				
	171	17.3	14 32	13 34	13 0	23.8	36.2				
	172	17.0	14.15	13.17	6.8	17.2	29.7				
	173	12.0	15 08	14.10	− 1.3	9.7	23.2				
	174	−19.5	13.82	12.84	5.2	15.2	27.5				
519	175	−15.3	15.05	14.07	−41.4	−27.7					
Sept. 11, '03	176	−15.7	14 43	13.45	−39.4	−26 3					
	177	−11.9	14 85	13.87	−39.7	−26.2					
	178	−22.4	13.61	12.63	− 0.6	11.7					
	179	−38.1	13.71	12.73	0.7	13.1					
	180	−39.7	14 23	13.25	− 1.0	11 9					
	181	−29.5	14 85	13 87	−19.0	− 5.5					
	182	−28 1	13.82	12.84	12 0	24.5					
	183	−31 5	13.41	12.43	14.0	26.1					
	184	−30 6	14.13	13 15	18.7	31.5					
	185	15.4	14.13	13.15	4 9	17.7					
	186	19 6	15.15	14.17	4 0	17 8					
	187	20 8	14.74	13 76	1.9	15.3					
	188	23 2	14 43	13 45	3.8	16.9					
	189	17.9	13 92	12 94	14.9	27.5					
523											
Sept. 12, '03											
580	1	−29 2	15.06	14 07	−25.9	−10.3					
Oct. 9, '03	2	−27 3	14.14	13.15	−30.0	−15.5	− 1.0				
	3	−28 0	14 70	13 71	−26 7	−11.5					
	4	−23 9	14 28	13 29	−35 3	−20.8	− 6 0				
	5	−19 2	13 19	12 20	−14.7	− 1.3	12.2				
	6	25 0	14 24	13 25	−14 8	− 0.1					
	7	24 3	14.33	13 34	−44 6	−29.8					
	8	−20 6	14 06	13 07	−40 5	−26 0					
	9	−20 2	13 61	12 62	−42 0	−28.0					
	10	−22 6	14.15	13 16	−44 5	−29 9					
	11	15 5	14 05	13 06	−26 6	−12.0	2 2				
	12	22 1	14 05	13 06	−21.7	− 7.5	7.1				
	13	−16 7	13 64	12 65	−23.7	− 9.3	4 2				
	14	17 1	14 60	13 61	14 5	29.6	44.5				
	15	16 6	14 46	13 47	12 2	27 2	41.9				
	16	16 5	14 10	13 11	9 8	24 2	38.7				
	17	11 4	14 97	13 98	7 2	22 7					
	18	12 9	14 60	13 61	6.1	21 3	36 1				
	19	14 6	14 60	13 61	3 2	18 8	33 2				
	20	20 0	14 64	13 65	− 3.9	11.2	26 2				
	21	20 2	13 82	12 83	12 2	26 2	40 5				
	22	22 5	14 24	13 25	10 9	25 6					
	23	26 7	14 33	13 34	− 2 0	12 8					
	24	29 2	15 87	14 88	3 7	18 0	32 1				
	25	18 1	14 51	13 52	31 9	46 9					
	26	−16 5	12 98	11 99	− 9 0	4.3					
	27	7 2	15 83	12 84	13 1	28.1	41 1				
	28	−12 7	14 06	13 07	−17 7	− 3 2					
	29	20 4	14 60	13 61	29 7	44 8					
	30	23 2	13 52	12 53	−16 5	− 2 6					
	31	22 9	14 31	13 33	23 3	38 0					
	32	19 0	13 82	12 84	−16 0	1 2					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
605	30	−24°.1	14°.31	13°.32	−14°.7	− 0°.1					
Oct. 10, '03	32	22.3	14.13	13.14	1.8	16.2					
10^h59^m	33	23.5	14.68	13.69	− 5.0	10.0					
611											
Oct. 11, '03											
1^h17^m											
828	190	18.0	14.33	13.32	7.2	18.0					
Mar. 7, '04	191	12.7	13.96	12.95	5.8	16.3					
2^h22^m	192	22.0	14.45	13.44	6.2	17.1					
	193	17.5	13.83	12.82	− 6.4	4.0					
	194	15.0	14.70	13.69	− 4.2	6.9					
	195	15.7	14.20	13.19	1.9	12.6					
	196	14.1	14.20	13.19	2.9	13.6					
	197	18.8	13.96	12.95	0.7	11.2					
	198	20.8	15.06	14.05	2.2	13.6					
	199	26.4	13.96	12.95	15.4	25.9					
	200	25.0	13.83	12.82	13.0	23.4					
	201	18.3	13.46	12.45	− 8.3	1.8					
	202	19.6	13.83	12.82	− 7.1	3.3					
	203	20.5	13.46	12.45	− 5.1	5.0					
	204	24.9	13.96	12.95	−19.3	− 8.8					
	205	26.7	14.08	13.07	−38.1	−27.5					
	206	26.5	13.83	12.82	−39.5	−29.1					
	207	21.2	13.71	12.70	−18.6	− 8.3					
	208	− 5.0	13.71	12.70	35.5	45.8					
	209	13.1	14.70	13.69	− 6.2	4.9					
	210	16.9	14.08	13.07	−10.6	0.0					
	211	17.3	13.59	12.58	−17.5	− 7.3					
	212	15.0	13.46	12.45	−15.0	− 4.9					
	213	13.0	14.33	13.32	−15.4	− 4.6					
	214	10.4	14.33	13.32	−16.5	− 5.7					
	215	17.0	15.19	14.18	−13.8	− 2.3					
	216	15.5	14.08	13.07	−13.6	− 3.0					
	217	−18.4	15.56	14.55	−22.0	−10.2					
	218	−17.8	14.70	13.69	−28.0	−16.9					
	219	−22.2	14.08	13.07	−24.6	−14.0					
	220	−32.3	14.94	13.93	−16.5	− 5.2					
	221	−30.8	13.59	12.58	− 6.1	4.1					
	222	−19.9	14.57	13.56	3.0	14.0					
	223	17.1	13.83	12.82	−22.0	−11.6					
	224	17.6	13.83	12.82	−20.5	−10.1					
832											
Mar. 8, '04											
9^h50^m											
854	225	−10.2	14.19	13.21	−24.2	− 8.8	4°.9		29°.3		
Apr. 12, '04	226	16.4	13.96	12.98	−19.9	− 5.7	6.8				
9^h26^m	227	11.7	14.73	13.75	−21.2	− 6.5	7.1				
	228	23.1	13.75	12.77	6.3	20.2					
	229	16.6	14.22	13.24	−16.9	− 2.2	10.3		36.7		
	230	−10.3	15.12	14.14	−17.1	− 1.7	12.0				
	231	−17.7	13.86	12.88	13.9	28.1	40.4				
	232	−16.7	14.76	13.78	18.1	33.1					
	233	−14.4	13.94	12.96	19.8	33.9					
	234	−12.8	14.76	13.78	17.0	32.0					
	235	−20.8	14.40	13.42	31.3	45.9					
	236	−17.0	14.30	13.32	28.0	42.5					
	237	−14.2	14.54	13.56	−24.0	− 9.1	3.9				
	238	−19.3	14.93	13.95	−19.5	− 4.1	9.2				
	239	−17.9	14.01	13.03	−28.5	−14.2	− 1.7				
	240	−14.3	14.59	13.61	−25.9	−10.9	2.1				
	241	−16.8	14.12	13.14	−17.0	− 2.7					
	242	−19.7	14.11	13.13	−40.1	−25.9	−12.9		12.9		

TABLE I—Continued

Field Number and Date	Number	Latitude	Daily Motion		Differences for Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
854 (*cont.*)	243	−20°0	14°39	13°41	29 5	34°9	48°1				
	244	−19.8	13 94	12 96	23 2	37.3					
	245	−20 3	14 73	13 75	−25 0	−10 0	3 3				
	246	−21.4	13 94	12 96	26 4	40 5					
	247	29 7	13 57	12 59	16 3	30 0					
	248	−13.4	14 00	13 02	−17.3	− 3.0	9 9		37 3		
	249	− 9.8	14 76	13 78	−20 2	− 5.2					
	250	21 8	13 57	12 59	−26 6	−12 9					
	251	20 2	14 12	13 14	−28 9	−14 6					
	252	12.4	13.73	12 75	−37.8	−23.1	−11.7		14.0		
	253	−16 4	14 21	13 23	7 3	21.7					
	254	−21.6	13 57	12 59	2.7	16.4					
	255	−20 9	13 90	12 92	5 9	19.7	32.5				
	256	22 8	14.12	13 14	− 4 8	9 5					
	257	30 5	12 83	11.85	−30.3	−17.7	− 5.9				
	258	38.8	9 89	8 91	−33 3	−23 6					
	259	34.1	13 66	12.68	−36 6	−12.8					
	260	43.4	12.10	11 12	− 7.0	5.1					
	261	53.9	12 38	11 40	−17.3	− 4.9					
	266	−21.7	14 04	13 06	−43.7	−30 2	−16 8				
858	262	−18.4	14 08	13 10	7 7	20 4					
Apr. 13, '04	263	−20 6	14 08	13.10	6.7	19.4					
11h34m	264	−21.7	13 87	12.89	8.2	20.7					
	265	−20 8	14.91	13 93	−28 9	−15.4					
	267	10 5	14 41	13.43	−37.7	−25 2		1°9		29°5	41°3
	268	11.3	12.74	11 76	−38.0	−26.6					
	269	11 9	13 98	13 00	−37 0	−24.4					
	270	16 2	13 98	13 00	−38 1	−25.5					
	271	15 8	14.22	13 24	−33 8	−22 9		4.9			
	272	7.5	14 49	13 51	3 2	16.3					
	273	10 9	14 55	13 57	1.3	14.1		41.3			
	274	9.8	14 57	13 57	− 3 9	9 6		35.7			
	275	−19.2	15 32	14 34	13 2	27.1					
	276	−20.1	15.11	14.13	−35.9	−22.2					
	277	4.1	14 55	13.57	−42.0	−28.3		− 0.8		26.5	38.1
	278	8.1	14 34	13 36	−41.7	−28.5		− 2.2			
	279	27.5	13.87	12.89	−45 9	−33.4					
864	280	22 3	14 18	13 20	2 1		28 3				
Apr. 14, '04	281	22 6	12 82	11.84	−28.9		− 5.4				
16h49m	282	−12.2	14 28	13 30	−48.0		−21.6				
	283	−14 8	14 40	13 42	−48.1		−21.9		6.1	18.0	
	284	19 6	14 44	13 46	−27.5		− 0.8				
	285	23 5	13 83	12 85	−24.4		1.1				
	286	13 0	13 95	12 97	−34.1		−10 5		16.2	28.9	44 3
	287	16 7	13 53	12 55	−40 5		−15.6				
867	288	− 6 2	14 99	14 01	−29 6		− 1.1	11.9			
Apr. 16, '04	289	−17 3	14 42	13 44	27 8		0 0	12 0	26 8		
10h29m											
869	291	−22 1	13 65	12 67	32 9		44.6				
Apr. 18, '04	292	−24 0	14 19	13 21	32 1		44.3				
11h24m	293	−23 1	14 84	13 86	28 0		40 8				
	294	7 2	14 19	13 21	25 5		37.7				
	295	8 7	14 30	13 32	24 6		36 9				
	296	16 1	13 86	12 88	29 1		41.0				
	297	17 3	13 86	12 88	26 9		38.8				
	298	14 6	14 08	13 10	21 5		33 6				
	299	9 1	14 62	13 64	20 9		33 5				
	300	8 2	14 45	13 47	18 2		30 0	45 1			
	301	22 2	14 08	13 10	15 2		27 3				
	302	16 7	13 49	13 36	13 5		25 7	40 5			
	303	17 9	12 66	11 68	10 8		21 5				
	304	16 9	13 97	12 99	14 5		26 5				
	305	7 1	15 00	14 02	12.0		24 3	40 3			
	306	12 5	13 54	12 56	10 8		22 4				
	307	11 2	13 76	12 78	9 3		21 1				
	308	21 6	14 64	13 66	7 0		15 8	29 9	41 2		

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
869 (*cont.*)	309	20°5	14°33	13°35	−22°9	−10°6	4°2	16°0			
	310	18.0	13.74	12.76	−22.3	−10.4	3.5				
	311	15.7	14.45	13.47	−20.6	− 7.9	6.6	18.8			
	312	15.9	14.36	13.38	−23.3	−11.0	3.5	15.8			
	313	13.9	14.84	13.86	−26.1	−13.3					
	314	16.3	14.73	13.75	−26.7	−14.0					
	315	17.3	13.65	12.67	−28.3	−16.6					
	316	15.1	13.76	12.78	−32.3	−20.8	− 6.8	5.0			
	317	17.5	14.51	13.53	−38.3	−25.8					
	318	21.8	14.00	13.02	−38.0	−25.5	−11.5	0.1			
	319	21.6	13.97	12.99	−40.3	−28.3					
	320	− 2.4	13.76	12.78	31 0	42.8					
	321	−16.6	14.62	13.64	5.0	17.6					
	322	−19.6	13.97	12.99	2.5	14.5					
	323	−26.0	13.76	12.78	31.8	43.6					
	324	26.6	14.30	13.32	26.5	38.8					
	325	20.8	13.97	12.99	21.1	33.1					
	326	16.0	13.86	12.88	2.1	13.9	28.5	39.5			
	327	13.1	14.26	13.28	1.6	13.8	29 0	40.1			
	328	18.7	14.19	13.21	2.0	14.2					
	329	26.2	13.97	12.99	4.4	16.2	30.7	42 2			
872	330	20.9	13.47	12 50	−20.2	− 6.2	4.7				
Apr. 19, '04	331	−22.9	14.34	13.37	−18.5	− 3.1	8.1				
9h31m	332	−17.4	14.64	13 67	19.9	34.9					
	333	−18.1	14.71	13.74	19 1	34.1	46.5				
	334	24.5	14.27	13 30	14.5	29.3	41.0				
	335	− 7.4	14.82	13.85	9.5	25.0	37.1				
876	336	− 4.5	14.81	13 84	27.8	40 2					
Apr. 20, '04	337	20.5	14.13	13 16	2 9	8.9					
11h52m	338	12.5	14.48	13.51	1.6	13.7					
	339	8.8	14.25	13.28	4.2	16.1					
	340	3.9	15.15	14.18	3.4	16.1					
	341	24.8	14.48	13.51	5.7	17.8					
	342	29.0	14.03	13.06	− 2.7	9.0					
	343	14.4	14.13	13.16	−30.9	−19.1					
	344	14.6	14.37	13.40	−34.8	−22.8					
	345	13.2	14.92	13.95	−40.4	−27.9					
	346	21.1	13.47	12.50	−14.1	− 2.9					
	347	20 8	14.03	13.06	−22.7	−11.0					
	348	21.0	15.03	14.06	−30.8	−18.2					
	349	26.8	14.13	13.16	−35.9	−24.1					
	350	14.0	14.37	13.40	− 9.3	2.7					
	351	−14.3	14.13	13.16	−48.1	−36.3					
881											
Apr. 21, '04											
9h22m											
891	352	−27.1	14.44	13.47	3.8	16.2					
Apr. 26, '04	353	−27.7	14.33	13.36	− 1.0	11.4					
12h00m	354	−15.8	14.44	13.47	− 5.0	7.5	21.7				
	355	−19.2	13.47	12.50	6.5	18.1					
	356	−17.3	14.47	13.50	− 7.8	3.5	18.9				
	357	−18.9	14.79	13.82	−14.4	− 1.2	13.0				
	358	17.8	14.19	13.22	− 2.3	10.0	23.9				
	359	18.0	14.55	13.58	−10.9	1.4	15.7	29.8	42°8		
	360	16.1	14.19	13.22	− 7.5	4.8	18.7				
	361	11.0	14.46	13.49	−10.7	1.8	16.0	29.7			
	362	9.5	14.29	13.32	−14.5	− 2.0	11.9				
	363	11.4	13.79	12.82	−13.8	− 1.9					
	364	12.6	14.12	13.15	−14.9	− 2.7					
	365	16.5	14.35	13 38	−15.9	− 3.8	10.6				
	366	21.5	13.90	12.93	−14.7	− 2.7					
	367	20.4	14.12	13.15	−19.8	− 7.6					
	368	23.7	14.09	13.12	−35.9	−23.7	− 9.9				
	369	17.0	14.39	13.42	−29.9	−17.6	− 3.3				

TABLE I (continued)

Plate Number and Date	Number	Latitude	Daily Motion		Longitude from Date of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
894 (cont.)	370	17°7	14°30	13°26	−26°0	−14°0	0°4				
	371	14 3	14 94	13 97	−26 6	−13.2	1.1				
	372	20 2	15 09	12 72	−35 8	−24.0					
	373	19.1	15 79	12 82	−20 5	− 8.6					
	374	−16 8	13 89	12 92	10 2	22 1	36 3	48°7			
	375	−18 1	14 98	14 01	32 1	45 1					
	376	−15 7	15 47	12 50	32 9	44.5					
	378	24 8	14 01	13 04	−33 1	−21 0					
	379	27 2	14 22	13 25	−32 3	−20 0					
	380	14 0	14 46	13 36	−17.2	− 5.4	7 9	22 2	35°8		
	381	−11 6	12 93	11.96	−15 7	− 4.6					
	382	−11 5	14 36	13.39	−10 0	1 3	16.1	29.8	42.7		
	383	− 6 8	13 03	12 66	− 5.3	6 1	20 0	32 4			
	384	− 8.0	13 90	12 93	−17.0	− 4.8	8.0	21.3	34.6		
	385	13 5	13 58	12 61	−35.2	−23.5					
	386	−17 5	14 44	13.47	−19 5	− 7.0					
	387	10 3	13 94	12 97	17.4	29 0	43 1				
	388	15 3	13 58	12 61	2 2	13.9	27.2				
	389	16 7	14 24	13 27	4 8	17 1	31.1				
897	390	−18.5	14 66	13 69	8.0	21.9	36 3				
Apr. 27, '04	391	−18.1	14 57	13 60	9 8	23 7	37.9				
10h16m	392	−15 6	14.48	13 51	15 0	29 4	42 9				
	393	8.9	14 09	13.12	10 2	24 2	37.3				
	394	17.5	14 06	13 09	12.3	26 1					
	395	20 6	14 06	13 09	6 7	20 4	33.6	46 5			
	396	22 0	14 35	13 38	8 0	22 1					
	397	22 7	13 87	12 90	6 3	19 9					
	398	14 0	14 44	13 47	4 9	9 3					
	399	18 0	14.15	13 18	6 7	7.0	20 2	33 4			
	400	14 1	14 46	13.19	−41 6	−27.7					
	401	−14 6	14.76	13.79	9 9	24.2	38 4				
	402	−18 4	14.63	13.66	1.0	15.4					
	403	−11.2	14 44	13.47	− 2 9	11.3					
906	404	−26.4	14.02	13.05	29 3	42.5					
Apr. 28, '04	405	−32 6	13 22	12 25	20 9	33.3					
11h34m	406	−28.9	13 82	12 85	20 9	33 9					
	407	−25.8	13 82	12 85	21.3	34.3					
	408	−17.0	14 72	13 75	7 4	21.5	34.7				
	409	11.8	14.02	13 05	18.7	31.9	44 6				
	410	−18 1	14 42	13.45	5.1	18 8	31.8				
	411	21.0	13.51	12 54	4.9	18.0	29 8				
	412	−15 4	14 32	13 35	6 0	19 9	32 5				
	413	−13 8	14 84	13.84	4.1	18.1					
	414	− 9.1	14 31	13 34	23 0	36 5					
	415	−12 7	14 37	13 40	20 7	34.3	47 3				
915	416	− 8 9	14 73	13 76	32 9	46 3					
Apr. 29, '04	417	−10 6	14 73	13 76	26 0	39 4					
11h51m	418	−18 0	14 32	13 35	30 9	43 9					
	419	−16 5	14 01	13 04	34 6	47.3					
	420	21 5	13 91	12 94	26 5	39 1					
	421	− 6 2	14 63	13 66	27 0	40 3					
	422	19 1	13 98	13 01	−15 7	− 3 2		24 7			
	423	15 4	14 03	13 06	−19 0	0 8		21 3	32 3		
	424	19 0	14 42	13 15	−10 9	1 9					
	425	15 0	14 01	13 04	− 4 2	8 5					
	426	26 9	13 50	12 43	4 1	16 2					
	427	18 9	13 78	12 81	−23 8	−11 8		15 1	25 8	38 9	
	428	24 0	13 58	12 59	−25 1	−12 9		13 0	23 3	37 0	
	429	20 2	14 08	13 09	−29 9	−17 7					
	430	18 4	13 63	12 66	−27 0	−15 3		11.4	22 0	34 9	
	431	22 5	14 49	13 52	−31 6	−19 5					
	432	21 5	14 01	13 04	−32 5	−19 8					
	433	18 1	13 71	12 74	−35 1	−22.7					
	434	17 3	13 91	12 94	−40 4	−27 8					
	435	22 9	12 88	11 91	−44 8	−33 2					
917	436	22 3	14 17	13 20	−39 5		−12 1	−1 8	19 0	25 3	
Apr. 30, '04											
11h12m											

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
919	437	22°0	14°14	13°18	25°6	36°0					
May 2, '04	438	25.2	14.40	13.44	25.1	35.7					
2h26m	439	14.2	13.13	12.17	20.4	30.0					
	440	21.0	14.90	13.94	6.9	17.9					
	441	24.5	13.76	12.80	5.7	15.8					
	442	16.2	14.02	13.06	2.6	12.9					
	443	17.6	13.92	12.96	− 2.3	8.2	21°1	34°0			
	444	20.6	14.08	13.12	0.0	10.9	22.8	37.1			
	445	21.0	14.40	13.44	− 1.4	9.2					
	446	21.5	14.65	13.69	− 2.7	8.1					
	447	23.4	14.78	13.82	− 2.1	8.8					
	448	13.9	14.90	13.94	−11.0	0.0					
	449	16.2	15.16	14.20	−11.3	− 0.1					
	450	17.8	15.16	14.20	−14.1	− 2.9					
	451	27.2	14.90	13.94	−14.9	− 3.9	10.8	24.6			
	453	24.3	15.03	14.07	−20.0	− 8.9					
	454	21.5	14.78	13.82	−19.9	− 9.0					
	455	20.2	14.52	13.56	−20.6	− 9.9					
	456	19.3	15.28	14.32	−26.4	−15.1					
	457	18.3	15.54	14.58	−26.6	−15.1					
	458	20.0	14.43	13.47	−31.1	−20.5	− 6.8	6.5			
	459	−24.8	14.14	13.18	− 7.4	3.0					
	460	−26.6	13.32	12.36	− 8.8	1.0	13.0	25.9			
	461	−22.3	13.80	12.84	−20 0	−10.2	2 6	15.9			
	462	−20.5	14.01	13.05	−20.5	−11.0	2.2	15.9			
	463	−17.9	14.50	13.54	−30.1	−19.3	− 6.1	7.9			
	464	26.3	14.52	13.56	−25.1	−14.4					
923	465	−19.4	14.55	13.59	−19.7	− 6.2					
May 3, '04	466	−20.2	14.69	13.73	−14.3	− 0.3	13.3				
9h22m	467	−25.3	14.65	13.69	−14.5	− 0.9					
	468	−23.3	14.84	13.88	−16.0	− 2.2	11.9				
	469	−23.6	14.09	13.13	−17.3	− 4.4	9.1				
	470	−23.4	14.55	13.59	− 3.3	10.2					
	471	−22.9	14.65	13.69	− 5.7	7.9					
	472	−25.3	13.84	12.88	− 5.8	7.3	20.1				
	473	14.3	14.69	13.73	10.5	24.2	38.1				
	474	−17.0	14.15	13.19	−33.3	−20.2					
	475	36.0	13.55	12.59	− 2.7	9.3	22.6				
	476	23.2	14.15	13.19	− 4.9	8.2					
	477	−18.4	14.55	13.59	36.3	49.8					
	478	−24.5	14.05	13.09	20.0	33.0					
	479	−16.1	13.95	12.99	25.9	38.8					
	480	38.8	12.74	11 78	−12.9	− 1.2					
	481	40.1	11.33	10.37	−16.0	− 5.7					
	482	12.2	14.44	13.48	14.7	28.1	41.8				
	483	10.4	14.86	13.90	13.1	26.9					
	484	9.3	14.05	13.09	4.3	17.3					
	486	−12.3	14.39	13.43	13.6	27.0	40.6				
	488	19.2	14.65	13.69	16.5	30.1					
	489	18.9	14.45	13.49	15.2	28.6					
928	490	23.2	14.13	13.17	25.7	39.1					
May 4, '04	491	20.8	14.13	13.17	25.8	39.2					
9h12m	492	17.2	14.32	13.36	13.3	26.9					
	493	18.3	14.62	13.66	12.4	26.3					
	494	18.1	14.43	13.47	10.7	24.4					
	495	16.2	14.82	13.86	10.3	24.4					
	496	20.4	15.02	14.06	8.1	22.4					
	497	17.1	14.32	13.36	6.7	20.3					
	498	20.6	14.13	13.17	4.8	18.2					
	499	18.5	14.72	13.76	3.1	17.1					
	500	21.2	13.64	12.68	3.2	16.1					
	501	−24.8	14.52	13.56	17.3	31.1					
	502	−21.2	14.43	13.47	−42.6	−28.9					
932											
May 5, '04											
9h37m											

TABLE I—Continued

Plate No. and Date	No.	Longitude	Difference of Means		Equations of Condition						
			Sidereal	Synodic	1	2	3	4	5	6	7
946	503	20°1	14°73	13°77	33°2	46.2					
May 20, '04	504	15.4	14.95	13.99	31.8	45.0					
0h 56m	505	16.0	15.16	14.20	29.3	42.7					
	506	12.4	14.73	13.77	27.7	40.7					
	507	15.1	14.42	13.46	26.7	39.4					
	508	22.6	14.31	13.35	23.5	36.1					
	509	25.9	14.20	13.24	22.2	34.7					
	510	16.3	14.20	13.24	−24.6	−12.1					
	511	12.0	14.84	13.88	−32.4	−19.3					
	512	18.0	14.52	13.56	−39.5	−26.7					
	513	14.8	14.31	13.35	−42.1	−29.5					
	514	17.8	13.89	12.93	−34.7	−22.5					
	515	14.5	14.31	13.35	−33.1	−20.5					
	516	12.1	14.84	13.88	−45.9	−32.8					
	517	13.7	14.10	13.14	−40.0	−27.6					
	518	11.5	14.84	13.88	−27.8	−14.7					
	519	36.9	13.57	12.61	−30.9	−19.0					
	520	23.5	14.20	13.24	−32.0	−19.5					
	521	−16.1	14.63	13.67	−37.0	−24.1					
	522	−14.0	14.42	13.46	−38.0	−25.3					
	523	−14.6	14.84	13.88	−41.0	−27.9					
	524	12.5	14.84	13.88	−43.0	−29.9					
	525	−13.4	14.31	13.35	− 4.2	8.4					
	526	18.9	13.77	12.81	0.8	12.9					
	527	−18.1	14.42	13.46	− 7.6	5.1					
	528	−21.3	13.99	13.03	−10.3	2.0					
951											
May 21, '04											
9h52m											
962	529	9.7	14.55	13.60	9.8	22.5					
May 31, '04	530	6.2	14.87	13.92	7.5	20.5					
11h56m	531	6.0	14.44	13.49	4.7	17.3					
	532	3.5	15.19	14.24	− 0.9	12.4					
	533	6.2	15.08	14.13	− 1.1	12.1					
	534	7.5	14.44	13.49	− 5.2	7.4					
	535	15.3	15.19	14.24	8.6	21.9					
	536	17.9	14.55	13.60	7.7	20.4					
	537	13.9	14.01	13.06	11.1	23.3					
	538	14.0	14.23	13.28	24.7	37.1					
	539	17.6	14.01	13.06	29.1	42.3					
	540	22.0	14.01	13.06	30.4	42.6					
	541	23.0	13.80	12.85	13.6	25.6					
	542	23.5	14.65	13.70	− 1.9	10.9					
	543	26.9	13.16	12.21	−15.2	− 3.8					
	544	19.7	14.01	13.06	−38.9	−26.7					
	545	−18.9	14.55	13.60	0.0	12.7					
	546	−35.4	14.12	13.17	2.4	14.7					
	547	−24.1	13.90	12.95	− 8.9	3.2					
	548	−22.7	13.80	12.85	−10.2	1.8					
	549	−21.5	13.69	12.74	−13.8	− 1.9					
	550	−30.1	13.69	12.74	−18.1	− 6.2					
	551	−28.4	14.33	13.38	−20.0	− 7.5					
	552	−22.8	13.90	12.95	−22.1	−10.0					
	553	−17.8	15.30	14.35	−25.2	−11.8					
	554	−19.5	14.33	13.38	−25.2	−12.7					
	555	−19.9	14.87	13.92	−30.7	−17.7					
	556	−22.8	14.87	13.92	−30.9	−17.9					
	557	−23.6	14.65	13.70	−33.1	−20.3					
	558	−25.2	14.48	13.49	−34.1	−21.7					
	559	−29.5	14.44	13.49	−35.7	−23.1					
	560	−26.1	14.91	13.88	−37.9	−25.7					
	561	−23.1	14.58	14.03	−35.9	−22.8					
	562	−16.0	14.41	13.46	10.9	23.1					
	563	−21.1	14.48	12.53	2.1	13.8					
	564	−20.4	13.80	12.95	− 5.4	6.1					
	565	−18.4	14.12	13.17	− 8.9	3.4					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
962 (*cont.*)	566	−21.0	14°.01	13°.06	−12°.0	0°.2					
	567	−27.6	14.55	13.60	−17.9	− 5.2					
	568	−16.0	14.01	13.06	−11.5	0.7					
	569	−18.4	14.87	13.92	−17.0	− 4.0					
	570	−20.5	14.44	13.49	−15.8	− 3.2					
	571	−17.0	14.87	13.92	−17.1	− 4.1					
	572	−10.0	14.01	13.06	−25.0	−12.8					
	573	− 4.8	14.33	13.38	−24.3	−11.8					
	574	21.1	13.69	12.74	−40.0	−28.1					
	575	23.6	13.37	12.42	−39.2	−27.6					
967 June 1, '04 10^h21^m											
972 June 8, '04 11^h14^m	576	−23.0	14.47	13.52	32.1	44.8					
	577	−19.2	13.62	12.67	30.4	42.3					
	578	−16.2	14.25	13.30	26.4	38.9					
	579	− 5.5	15.11	14.16	25.2	38.5					
	580	− 7.3	14.79	13.84	14.8	27.8					
	581	0.8	15.53	14.58	5.3	19.0					
	582	− 9.5	14.15	13.20	− 0.4	12.0					
	583	−15.8	14.32	13.37	0.7	13.1	27°.2	39°.4			
	584	−19.0	13.83	12.88	− 0.3	11.8					
	585	−10.0	14.68	13.73	28.6	41.5					
	586	−24.9	14.04	13.09	9.4	21.7					
	587	−30.0	14.38	13.43	8.3	21.1	35.0				
	588	−22.2	13.57	12.62	− 4.0	8.0	21.1				
	589	14.7	14.79	13.84	− 9.3	3.7					
	590	−19.0	13.83	12.88	−10.0	2.1					
	591	−22.5	13.73	12.78	− 8.1	3.5	17.3				
	592	−30.4	13.16	12.21	− 4.0	6.4	20.0	31.1			
	593	−36.9	14.36	13.41	− 5.7	6.9					
	594	−14.9	14.68	13.73	−13.9	− 1.0					
	595	−20.4	13.88	12.93	−20.1	− 8.2	5.6				
	596	−39.8	12.77	11.81	−12.9	− 1.8	14.3				
	597	9.1	15.64	14.69	− 8.0	5.8					
	598	11.4	13.19	12.24	− 6.7	4.8					
	599	9.8	14.21	13.26	−11.2	1.2	15.4	27.1			
	600	15.5	14.46	13.51	− 5.8	6.9	20.9	33.4			
	601	19.0	14.15	13.20	−27.3	−14.9					
	602	17.6	14.15	13.20	−28.9	−16.5					
	603	16.0	14.15	13.20	−30.2	−17.8					
	604	15.5	13.72	12.77	−32.0	−20.0					
	605	19.7	12.66	11.71	−32.4	−21.4					
	606	20.8	13.83	12.88	−23.1	−11.0					
	607	21.7	14.23	13.28	−18.7	− 6.2	7.5	19.7		47°.1	
	608	18.3	14.43	13.48	8.2	20.9	35.0				
	609	15.2	13.93	12.98	12.5	24.7					
	611	20.9	14.04	13.09	29.1	41.4					
	612	23.2	14.15	13.20	30.8	43.3					
	613	18.2	13.30	12.35	31.8	43.4					
	614	27.8	12.87	11.92	10.9	22.1					
	615	−21.2	14.57	13.62	10.3	23.1					
	616	−32.7	13.40	12.45	− 0.1	11.6					
	617	33.5	14.57	13.62	24.2	37.0					
976 June 9, '04 9^h47^m	618	−18.3	13.35	12.40	24.2	37.2					
	619	−17.9	13.35	12.40	25.5	38.5					
	621	−23.1	13.77	12.82	16.2	29.6	41.3				
	622	14.9	14.59	13.64	− 5.1	9.1	21.6				
	623	26.3	14.67	13.72	13.2	26.8	40.1				
	624	24.4	13.54	12.59	18.8	32.0					
	625	21.7	14.03	13.08	19.9	33.7	45.5				
	626	8.3	14.94	13.99	− 8.1	6.2	19.3				
	627	8.7	14.78	13.83	−13.4	1.1					
	628	6.1	14.55	13.60	1.5	16.1	28.1				
	629	−19.0	14.20	13.25	6.0	19.9					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
976 (*cont.*)	630	−16°8	13°78	12°83	−40°1	−26°0	−14°7		11°8	24°6	
	631	−17.2	14 49	13 54	−42 7	−28.5					
	632	−16.3	14 12	13.16	−41 1	−26 3					
	633	−23 5	14 20	13 25	−19 3	− 5.4					
	634	−22 9	13 72	12 77	−21.5	− 8.1					
	635	−22 2	14 49	13 54	−24 3	−10.1					
	636	−25.6	13 82	12 87	−27.9	−14.4					
982	637	16 6	14 28	13 33	1.2	14.0		40°9			
June 10, '04	638	13.2	14 04	13 09	14 3	26 2					
10h57m	639	14.8	14.81	13.86	19 0	31.6					
	640	− 2.8	14 37	13 42	8 2	20 4					
	641	15.6	14 15	13 20	− 6.0	6 0					
	642	16 8	14 26	13.31	−10.2	1 9					
	643	24.2	14.26	13 31	3.1	15 2					
	644	−27.9	13.71	12 76	31.5	43.1					
	645	−28.7	13.93	12 98	26.1	37.9					
	646	−29.5	13.71	12.76	23.7	35.3					
	647	27.0	13.34	12 39	− 9.5	2.0		27.3			
989	648	11 6	14 42	13.47	21.2		48.9				
June 11, '04	649	11.8	14 91	13 96	−20.1		8 6				
8h40m											
994	650	17.4	13.94	12 99	8.7	21.9					
June 13, '04	651	21.5	14.63	13 68	8.0	21.9					
10h07m	652	25.5	14 34	13 39	8.4	22.0					
	653	24.6	13.94	12 99	6.4	19.6					
	654	29 4	13 84	12 89	6.0	19.1					
	655	27 9	13.74	12 79	1 9	14.9					
	656	28 6	14.53	13.58	10.0	23.8					
	657	30 1	13.94	12 99	− 0.8	12.4					
	658	19.8	14.53	13.58	37.1	50.9					
1004	660	6.7	14.58	13.63	− 3 9		22.9				
June 14, '04	661	10 7	14 45	13.48	− 3 8		22.7				
10h50m	662	11.8	14 38	13.43	− 1.0		25 4				
	663	18.1	14.64	13 69	− 1.8		20.1				
	664	22 6	14 17	13.22	− 1.7		24.3				
	665	14 2	14.64	13 69	7.0		33.9				
1007	666	9 5	14.45	13 50	−29 2	−15 6	− 2.4				
June 16, '04	667	7 0	14 20	13 25	−32 5	−18.7	− 6.2				
9h41m	668	8 5	14 36	13 41	−37.5	−23.2	−10 9				
	669	10 2	14 10	13 15	−37.1	−23.1	−11.5		15.6	28.9	41°9
	670	8 0	13 80	12 85	−39 6	−26.1					
	671	9 1	13 90	12 95	−40 0	−26 5	−14.3				
	672	10 4	14 56	13 61	−43.2	−28.0	−16.2				
	673	12 3	14 18	13 23	−44.4	−30 5					
	674	13 9	14 28	13.33	−38 9	−24 9					
	675	16 1	14 18	13 23	−39 0	−25.5	−13.1		14.1		
	676	17.4	14 25	13 30	−37.8	−24.1	−12 5		15.7		
	677	17 3	14 15	13 20	−40.7	−26 9	−14.5				
	678	17 4	13 98	13 03	−43 9	−30 5	−18 2		8.4		
	679	17 8	14 09	13 05	−46 4	−33.0	−20 8		6.0		
	680	−21 6	14 11	13 16	−40 1	−26 1	−14.0				
	681	−18 4	14 37	13 42	−42 3	−28.2					
	682	−22 8	14 18	13 23	−44 4	30 5					
	683	14 1	14 85	13 90	25 5	40 1					
	684	11 9	14 66	13 71	28 4	42 8					
1013	686	12 5	14 24	13 29	−10 4	2 0					
June 17, '04	687	16 7	14 13	13 18	−15 9	− 3 1		23 4	36 5		
10h34m	688	13 5	14 88	13 93	−16 0	− 3 0					
	689	9 0	14 88	13 93	−16 9	− 3 9					
	690	6 1	14 99	14 04	−23 3	−10 2					
	691	18 0	13 97	13 02	−40 2	−28 7		− 1.0	10 8		
	692	16 3	13 91	12 96	−42 5	−30 4					
	693	−15 1	14 77	13 82	−23 1	−10 2					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1013 (*cont.*)	694	−12°0	14°42	13°47	−24°0	−11°9		15°9			
	695	−14.8	14.02	13.07	−28.0	−15.8					
	696	−12.0	14.66	13 71	−27.8	−15 0					
	697	−14.0	13.81	12 86	−29 5	−17.5					
	698	−10.9	14 66	13 71	−29.8	−17.0					
	699	−17.6	14.02	13.07	−29.8	−17.6					
	700	−19.6	13.27	12.32	−33.8	−22.3					
	701	−26.6	14.02	13.07	−33.1	−20.9					
	702	−18.8	14.02	13 07	−37.9	−25.7					
	703	−20.7	15.84	14.89	−30 9	−27.0					
	704	−11.2	14.02	13.07	−42.2	−30.0					
	705	−27.1	13.16	12.21	−25.0	−13.6					
	707	−13.5	13.70	12.75	−39.5	−27.6					
1017	708	18.4	13.89	12.94	−34.2		− 7°3	5.2	17°9		
June 18, '04	709	17.5	14.39	13.44	−39 3		−11.2	1.8	15.0	28°5	
9^h18^m	710	8.8	14.48	13.53	−20.7		6.2	20.0	33.8		
	711	8 6	14.18	13.23	−23.2		3.7	17.0	30.0		
	712	6.0	14.17	13.22	−21.9		5.2	18.1			
	713	19.6	14.54	13.59	−14.9		13.0	26.2	39.9		
1025	714	15.9	13.86	12.91	10.6	23.0	36.3				
June 20, '04	715	10.1	14.47	13 52	11.3	24.2	38.2				
10^h10^m	716	19.5	14.34	13.39	20.7	34.0					
	717	−28.1	13.74	12.79	12.9	25.6					
	718	14.5	13.76	12.81	18.9	31.2	44.4				
	719	16.0	14.14	13.19	4.4	17.5					
	720	14.4	14.34	13.39	21.3	34.6					
	721	17.0	14.40	13.45	1.3	14.2	27.8	41.5			
	722	18.3	14.31	13.36	−15.1	− 1.2	11.8	25.0			
	723	17.5	14.24	13.29	−17.1	− 3.9					
	724	−19.2	14.54	13.59	10.0	23 5					
	725	−17.8	14.65	13.70	10.2	23.8					
	726	−19.4	14.57	13.62	7.9	21.2	35.0				
	727	−14.6	14.24	13.29	4.1	17.3					
	728	−15.8	13.94	12.99	0 0	12.9					
	729	−20.0	14.21	13.26	0.5	13.5	26.9				
	730	−23.6	13.36	12.41	− 0.6	12.1	24.1				
	731	−20.7	14.22	13.27	−27.7	−14.1	− 1.4	12.2			
	732	−20.8	14.49	13.54	−29.9	−16.1	− 2.8	10.7			
	733	−15.9	13.84	12.89	−31.0	−18.2					
	734	− 5.1	14.47	13.52	− 4.9	8.7	22.0				
1030	735	−17.8	14.89	13.94	27.1	41.0					
June 21, '04	736	−16.8	13.89	12.94	25.6	38.5					
10^h00^m	737	−13.5	14.39	13.44	21.1	34.5					
	738	−10.9	14.39	13.44	9.5	22.9					
	739	18.8	14.09	13.14	20.9	34.0					
	740	9.7	14.69	13.74	22.1	35.8					
	741	−22.9	14.50	13.55	18.2	32.1	45.3				
	742	−27.3	14.29	13.34	18.6	31.9					
	743	14.6	14.29	13.34	−37.9	−24.6					
	744	16.7	13.99	13.04	−37.1	−24.1					
	745	22.7	14.29	13.34	−40.1	−26.8					
	746	22.9	14.19	13.24	−42.4	−29.2					
	747	25.6	14.79	13.84	−44.9	−31.1					
	748	30.0	12.38	11.43	−40.0	−28.6					
	749	−23.1	13.79	12.84	15.3	28.1					
	750	−29.7	13.90	12.95	16.8	30.0	42.7				
	751	−28.0	13.70	12.75	11.7	24.1	37.2				
	752	14.4	14.39	13.44	11.4	24.8					
	753	−28.9	14.46	13.51	3.0	16.2	30.0				
	754	−50.8	7.87	6.92	28.0	34.9					
	755	−45.5	9.78	8.83	− 8.8	0.0					
1035	756	19.3	14.01	13.06	−23.6	−10.5					
June 22, '04	758	−19.9	14.01	13.06	12.8	25.9					
9^h56^m	759	20.6	14.71	13.76	24.2	38.0					
	760	18.7	13.89	12.94	22.8	35.8					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Period of Rotation		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1039 June 23, '04 10h00m5											
1051 July 1, '04 9h21	761	21 9	14 93	12°98	28°3	41 2					
	762	23 1	13 63	12 68	31.7	44.3					
	763	−19 7	14.43	13 48	32 0	45.4					
	764	−17 6	14.43	13 48	− 5.5	7.9					
	765	22 8	14.84	13.89	12 2	26.0					
	766	27 7	13 73	12 78	− 1.6	11.1					
	767	22 4	14 23	13 28	27.1	10 4					
	768	19 6	13 93	12 98	− 4.7	8 2					
	769	25 2	14.13	13.18	−10.9	2.2					
	770	16 8	13.93	12 98	− 8.4	4.5					
	771	14 2	13.93	12 98	−14.6	− 1.7					
	772	13 5	14.74	13.79	−20 7	− 7.0					
	773	12 7	14.13	13 18	−23.7	−10.6					
	774	22 1	14.33	13.38	−42 5	−29.2					
	775	19 8	14.43	13.48	−41.9	−28.5					
	776	17 1	13 53	12 58	−35 8	−23.3					
	777	−15 9	13 63	12 68	−11.2	1.4					
	779	−20 6	14.13	13.18	−29.1	−16.0					
	780	22 9	13 83	12 88	−28.7	−15.9					
	781	30 0	13.73	12 78	0.5	13.2					
	782	37 7	13 53	12.58	− 2.5	10 0					
	783	38 5	13.93	12 98	23 2	36.1					
	784	−26 6	14.03	13.08	8.2	21.2					
	786	23 0	14.13	13 18	25 0	38.1					
	787	−23 6	14.03	13.08	22 5	35.5					
	788	17.3	13 93	12 98	8.8	21.7					
	789	12 3	13.93	12 98	10 3	23.2					
	791	15 3	12 32	11 37	− 1.2	10.1					
	792	−17 9	14.33	13 38	−13 0	0 3					
1054 July 2, '04 9h12											
1068 July 12, '04 9h51	793	19 3	14.56	13 61	−26.8	−13.5					
	794	23 6	14 11	13 16	−25.9	−12.9		13°0			
	795	25 7	14 32	13 37	−29 1	−16.0		10.4			
	796	17 2	14 87	13 92	−16 0	− 2.4					
	797	15 0	14.66	13 71	−22 3	− 8.9					
	798	21 3	14.41	13 46	−30 2	−16 4		19 2	23 9		
	799	16 6	14 36	13 61	−32 2	−18 9					
	800	18 2	14 05	13 10	−30 8	−18 0					
	801	19 8	12 92	11 97	5.5	17.2					
	802	29 2	12 41	11 46	3.1	14 3					
	805	25 0	14 05	13 10	7 2	20 0					
	804	16 8	14 87	13 92	6 4	20.0					
	805	12 6	15 69	14 74	12 8	27.2					
	806	17 2	14 87	13 92	18 3	31 9					
	807	35 2	14 05	13 10	35 8	34 4					
	808	12 6	14 24	13 29	−37 3	−24 5		2 2			
	809	18 8	15 59	14 64	−15 8	− 7.5					
	810	−25 4	12 42	11 47	23 1	34 8					
	811	−24 7	13 54	12 59	21 1	33 4					
1072 Mar 13, '04 8h01	813	−15 0	13 80	12 95	−30 5		1 8				
	814	8 7	14 65	13 70	20 1		6 4	20 1			
1073 Mar 15, '04 8h37	804	18 3	13 83	12 97	3 1	11 9					
	815	32 8	14 48	13 53	− 5 1	6 5					
	816	19 9	14 48	13 53	− 9 3	6 2					
	817	10 8	14 68	13 73	−13 9	0 7					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1075 (*cont.*)	818	−15°6	14°21	13.26	−12°9	2°2		27°3			
	819	−16.5	14.01	13.06	−18.0	− 4.1					
	820	−25.6	14.58	13.63	−19.1	− 4.6					
	821	−24.4	14.30	13.35	−12.1	− 2.1					
	822	−20.5	14.59	13 64	−10.5	1 9		30.8			
	823	−29.4	14.77	13 82	−26 9	−12.2					
	824	−31.8	15.42	14.47	−32.0	−16.6					
	825	−25.6	14.39	13.44	−26 8	−12.5					
	826	−21.5	14.48	13.53	−25.0	−10.6					
	827	10.4	14.36	13.41	− 2.5	12.0		38.0			
	828	19.6	14.26	13.31	− 8.8	5.7		31.4			
	829	16.7	14.29	13.34	−13.5	1.0		26.8			
	830	12.0	12.60	11.65	− 9.9	2.5					
	831	12.4	13 83	12.88	−20.4	− 6.7					
	832	16.5	13.92	12 97	−20.8	− 7.0					
	833	17.9	14.01	13.06	−24.4	−10.5					
	834	16.5	14.39	13.44	−27.5	−13.2					
	835	19.1	13.83	12.88	−28.8	−15.1					
	836	19.5	13.73	12.78	−32.5	−18.9					
	837	15.3	14.48	13.53	−30.0	−15.7		10.8			
	838	19 6	14.48	13.53	22.8	− 8.4					
	839	16.1	14.48	13.53	13.6	28.0					
	840	35.2	13.54	12 59	22.5	35 9					
	841	26.3	13 98	13 03	−22.8	− 9.5		16.4			
	842	15.5	14.01	13 06	− 9.3	4.6					
	843	16.9	13 83	12 88	− 6.8	6.9					
	844	18.9	13.73	12.78	3.8	9.8					
	845	12.9	14.68	13.73	18.3	32.9					
1085	846	13.8	13.95	13 00	16 6		42°0				
July 16, '04	847	−25.1	14.11	13.16	−13.6		12.1				
10h20m	848	−22.3	13.95	13.00	−14.0		11.4				
	849	−19 5	14.11	13.16	−13.7		12.0				
	850	−19.9	14.06	13.11	−17.4		8.2				
	851	13.1	14.78	13.83	−10.8		16 2				
	852	15.3	13.95	13.00	−20.0		5 4				
	853	16.9	14.42	13.47	−23.8		2.5				
1089	855	−16.0	14.61	13.66	−34.4		− 7.2				
July 18, '04	856	−22.1	14.52	13.57	−36.3		− 8.8	5.2	17°9	32°2	
9h12m	857	−17.7	13.74	12.79	−46.5		−21.0				
	858	10.3	14.25	13 30	12.5		39.0				
	859	11.2	14.55	13.60	−32.4		− 5.3				
1097	860	11.2	14.59	13.64	−24.8	−11.1	2.2	17.0			
July 20, '04	861	15.4	13.91	12.96	−11.9	1.3	14 1	27.8			
9h01m	862	17.2	13.85	12.90	− 8.3	4.1	17.1				
	863	22.3	13.96	13.01	−19.7	− 5.9	5.9				
	864	20.1	14.16	13.21	−20.5	− 7.2	5.5				
	865	18.7	14.23	13 28	−23.4	−10.3	3.0	17.2			
	866	22.7	13.62	12.67	−26.3	−13.6	− 0.4	12.3			
	867	24.3	14.38	13.43	−27.5	−14.1					
	868	− 6.8	14.12	13.17	−34.2	−20.7	− 7.9	6.7		32.2	
	869	− 2.1	14.88	13.93	−34.1	−20.2					
	870	− 1.1	14.23	13.28	−37.9	−24.0	−12.5	3.0		29.1	
	871	10.9	14.08	13.13	−42.1	−29.0					
	872	13.3	14.21	13.26	−39.4	−26.3	−13.3				
	873	−13.3	14.58	13.63	31.4	45.0					
1103	875	10.7	14.67	13.72	22.4	35.7					
July 21,' 04	876	12.0	14.88	13.93	4.2	17.7					
8h58m	877	−17.8	14.15	13.20	11.0	23.8					
	878	−24.4	14.68	13.73	4.5	12.8	32.9				
	879	−16.0	14.11	13.16	− 2.8	9.5	24.4				
	880	−21.3	14.20	13.25	− 0.2	12.2	27.2				
	881	−19.3	14.15	13.20	− 6.1	6 7					
	882	−26.0	13.33	12.38	− 2.7	9.3					
	883	−25.0	14.29	13.34	− 6.1	6.7	21.5				
	884	−22.1	14.06	13.11	−10.9	1.2	16.2				
	885	− 8.3	13.96	13.01	− 2.8	9.6	24.1				

TABLE I—(*Continued*)

Plate Number and Date	Number	Latitude	Distance Measure		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1103 (*cont.*)	886	− 6°6	14^{m}05	13^{m}10	− 6°7	6 2	20°4				
	887	−21 2	14 05	13 10	18 7	− 6 0					
	888	−15 9	14 56	13 61	−25 3	−12.1					
	889	− 8 0	14 15	13 20	−26 8	−14.0					
	890	11 6	14 14	13 19	− 7.2	6 0	20.1				
	891	13 9	14 44	13.49	−12 9	− 0.1	15.0				
	892	17 8	13 90	12.95	−17 0	− 4.3	9.8				
	893	23 2	13 59	12 64	−19 0	− 6.2	7 2		32°2		
1108 July 22, '04 8^{h}44^{m}	894	−21 2	14 33	13 38	20 0	34.7					
	895	1.6	14 60	13 65	−11.0	4 0					
1113 July 23, '04 10^{h}47^{m}	896	23 7	13 81	12 86	13 9		39.2				
	897	−10 9	13 67	12 72	1.4		26 4				
	898	−17 8	14 03	13 08	−24 5		1.3		26.8		
	899	21 4	13 81	12 86	19 8		45.1				
1118 July 25, '04 9^{h}49^{m}	900	−19 0	13 84	12 88	1 2		26 3	39°0			
	901	24 5	13 80	12 84	−28 5		− 3.6	9.2			
	902	−16 7	14 56	13 60	−48 5		−22.0	− 8.6			
	904	−21 0	14 19	13 23	−44.5		−18.6	− 5.7			
	905	29 1	13 51	12 55	38 0		−13.5	− 1.2			
	906	−20 8	13 62	12 66	2 0		22.5				
	907	27.4	13 79	12 83	−38 4		−13.2	− 0.8			
1122 July 27, '04 8^{h}45^{m}	903	−15 3	14 13	13 17	−24.3	−11.1					
	908	18 8	14 43	13 47	8 5	22 0					
	909	19 6	14 63	13 67	7 3	21 0					
	910	17.6	14 73	13 77	7 0	20 8					
	911	12 1	14 53	13 57	24 9	38 5					
	912	13 7	13 53	12 57	17 9	30 5					
	913	9 0	14.13	13 17	−11 3	1.9					
	914	17 2	13 83	12 87	− 1 0	11.9					
	915	20 4	14 43	13 47	− 0.3	13.2					
	916	22 6	14 23	13 27	0 6	13 9					
	917	17.7	14 03	13 07	− 4.0	9 1					
	918	17 7	14.63	13 67	− 7.5	6 2					
	919	24 5	14 23	14 27	−15 6	− 2.3					
	920	24 8	13.13	12 17	−18 2	− 6 0					
	921	16 0	14 43	13 47	3.8	17 3					
	922	18 8	14 23	13 27	2.5	15 8					
	923	18.5	14 13	13 17	−21 3	− 8.1					
	924	15 7	14 33	13 37	20 2	− 6.8					
	925	−22 5	14 53	13 57	−15 4	− 1.8					
	926	−19 6	14 13	13 17	−16 9	− 3.7					
	927	−22 1	14 53	13 57	−21 0	− 7.4					
	928	−28 1	13 93	12 97	26 0	−13 0					
	929	−26 9	14 63	13 67	31 0	−17 3					
	930	−23 8	14 43	13 47	−29 5	16 0					
	931	−24 8	14 03	13 07	−35 5	22 4					
	932	−19 8	14 03	13 07	−39 0	−25 9					
	933	14 8	15 73	14 77	−25 3	−10 5					
	934	14 0	14 73	13 77	−36 7	22 9					
	935	15 7	14 63	13 67	−36 7	−23 0					
	936	−18 5	14 23	13 27	9 9	−16 7					
	937	−31 2	12 83	11 87	22 9	34 8					
	938	−30 5	14 04	13 08	17 8	30 9					
	939	−25 8	13 83	12 87	11 0	26 9					
	940	−26 5	14 23	13 27	6 4	19 7					
	941	9 0	15 23	14 27	23 3	−11 2					
	942	−18 5	15 [illegible]	14 27	−23 9	− 9 6					
	943	−19 0	15 33	14 37	−25 4	11 0					
	944	−18 5	14 33	13 44	14 2	0 2					
	945	−16 8	13 [illegible]	12 77	3 7	1 7					
1126 July 30, '04 8^{h}44^{m}											

TABLE 1—*Continued*

PLATE NUMBER AND DATE	NUMBER	LATITUDE	DIURNAL MOTION		LONGITUDES ON DAYS OF OBSERVATION						
			Sidereal	Synodic	1	2	3	4	5	6	7
1142	946	−24°3	13.05	12.09	− 4°0	8°1					
Aug. 1, '04	947	−17.1	13.87	12.91	− 7.9	5.3	17°9				
8^h32^m5	948	−21.1	13.65	12.69	− 11.0	1.7					
	949	−18.7	13.07	12.11	− 18 0	− 5.9	6.2				
	950	−16.4	13.55	12 59	− 14.4	− 1.8					
	951	−24.7	13.25	12 29	29 7	42.0					
	952	−19.1	13.45	12 49	31 6	44.1					
	953	−20.0	13.95	12 99	23.5	36 5					
	954	−14.7	13.45	12.49	22 8	35 3					
	955	−21.3	14.12	13.16	20 1	33.3	46.4				
	956	−20.6	13.87	12.91	17 2	30.1	43.0				
	958	10.8	14.55	13 59	31.1	44.7					
	959	13.7	13.65	12.69	33.9	46.6					
	960	16.7	13 95	12 99	30 3	43.3					
	961	11.2	13.72	12.76	5 0	18 5	30.5				
	962	18.8	14.12	13.16	4 5	17.6	30.8				
	963	14.2	13.87	12.91	− 0.3	12 4	25.5				
	964	16.3	13.62	12.66	− 1.8	10.9	23.5				
	965	18.9	13 72	12 76	− 0.5	12 2	25.0				
	966	19.7	14.27	13.31	− 4.3	8.7	22.3				
	967	22.6	13.92	12.96	− 6.8	6.4	19.1				
	968	10.4	13.77	12.81	− 3.5	9.4	22.1				
	969	14.3	13.87	12.91	− 9.7	3.3	16.1				
	970	17.2	15.15	14.19	− 8.6	5 6					
	971	25.5	14.57	13.61	−14.3	− 0.7	12.9				
	972	30.5	13 62	12 66	−15.2	− 2.7	10.1				
	973	18.4	14.17	13.21	−18.5	− 5.7	7.9				
	974	12.5	14.22	13.26	− 3.8	9.4	22.7				
	975	28.4	13.65	12.69	2.2	14.9					
	976	29.8	13.65	12.69	1.2	13.9					
	977	31.8	13.45	12 49	0 2	12.7					
	978	37.1	12.45	11.49	0.5	12.0					
	979	50.0	11.14	10.18	5.7	15.9					
	980	40 6	12.85	11.89	21.0	32.9					
	982	15.1	13.25	12.29	−33.2	−20.9					
	983	12.1	13.77	12.81	−35.1	−22.4	− 9.5				
	984	11.7	14.25	13.29	−40.3	−27.0					
	985	11.9	14.37	13.41	−42.0	−29.3	−15.2				
	986	−26.3	12.55	11.59	15.3	26.9					
	987	14.1	13.62	12.66	−42.1	−29.9	−16.8				
	988	− 4.6	13.55	12.59	−15.7	− 3.1					
1147	989	−15.7	12.89	11.93	− 5.1	6.8					
Aug. 2, '04	990	19.7	13.50	12.54	−18.3	− 5.8					
8^h34^m	991	22.1	13.50	12.54	−20.0	− 7.5					
	992	19.6	14.60	13.64	−24.9	−11.3					
	993	13.2	14.20	13.24	−27.8	−14.6					
	996	10.7	13.70	12.74	− 1.4	11.3					
	997	19.7	14.00	13.04	− 1.2	11.8					
	998	21.7	14.40	13.44	− 0.6	12.8					
	999	22.2	13.90	12.94	1.2	14.1					
	1000	17.7	13.70	12.74	1.5	14.2					
	1001	11.1	14.50	13.54	6.5	20.0					
	1002	14.0	13.50	12.54	6.8	19.3					
	1003	−14.6	13.30	13.34	7.5	20.8					
1154											
Aug. 3, '04											
8^h30^m											
1160	1004	6.7	15.43	14.47	−42.9		−14.1				
Aug. 6, '04	1005	12.4	14.68	13.72	−41.1		−13.8				
9^h32^m	1006	24.8	13.32	12.36	−23.8		0.8				
	1007	28.4	13.87	12.91	−25.1		0.6				
	1008	28.2	14.02	13.06	−30.1		− 4.1				
	1009	26.0	14.02	13.06	−32.1		− 6.1				
	1013	25.9	13.63	12.67	21.3		46.5				

TABLE I (*Continued*)

Plate Number and Date	Number	Exposure	Duration of Minute		Residuals in Declination Depending on Observations						
			Sidereal	Standard	1	2	3	4	5	6	7
1160 (*cont.*)	1014	29 .3	13°17	12°21	15°0	...	39 .3			...	...
	1015	21 .5	14 ..	13 67	10.4		37 .5				
	1016	22 .2	12 62	11.66	5 0		28 .2				
	1017	25 .5	13 87	12 91	5.2		30 .4				
	1018	24 .4	13 32	12 36	4 0		28 .6				
	1019	20 .3	13 27	12 31	2.8		27 .3			...	...
	1020	8 .9	14 48	13 52	−47.4		−20 5				
	1021	30.3	13 87	12 91	−31.6		− 5.9				
	1022	32 .5	13.47	12.51	−36 3		−11.4				
	1023	16 .4	14.83	13 87	−43 6		−16 0				
	1026	26 .8	13.67	12.71	−19 8		5.1			46 .3	
1167	1024	18 .9	14 02	13 06	−20.9			18°0	...	...	...
Aug. 8, '04	1025	20 .9	14 05	13 09	−22.2			16.8			
9h17m.5											
1173	1030	10 .0	14 .52	13.55	27 .2	40 .7					...
Aug. 11, '04	1031	7.6	14 32	13.35	21 .9	35 .2					
8h45m.5	1032	15 .3	14.42	13.45	21 .9	35.3					
	1033	11 .9	14.42	13.45	15.7	28 .9	42 .9	...	...	...	...
	1034	11 .0	15 .02	14.05	12 .8	26 .8					
	1035	10 .5	14 .32	13 .35	9 .8	24 .0	37 .2				
	1036	11.6	14 42	13 45	7.3	20 .9	34 .5				
	1037	10 .7	14 22	13 25	3 .9	17.1	30 .7				
	1038	6 .7	14 .52	13 .55	8 .8	22 .3					...
	1039	0 .6	14 .82	13 .85	0 .5	14 .3	28 .5				
	1040	15 .1	14 37	13 .40	13 .9	27.5	41 .0				
	1041	16 .8	14 22	13 25	13 .0	26.1	39 .8				
	1042	18 .8	14 77	13 .80	10 .9	24 .5	38 .8				
	1043	19 .1	14 06	13.06	6 .6	20 .0	33 .0				
	1044	17 .0	14 32	13 .35	3 .9	17.5	30 .9				
	1045	23 .2	14 12	13.15	−16 .0	− 2.9					
	1046	14 .5	13 .83	12 .86	−27 .3	−14.8	− 1.3			...	...
	1048	17 .8	12 61	11 .64	−25 .4	−13.8					
	1049	14 .3	13 .81	12 .84	−21.7	− 8.9					
	1050	−16 .2	13 .83	12.86	− 6.7	6.3	19 .9				
	1051	−16.1	14 22	13.25	−10 .4	2 .8	16.4				
	1052	−20 .3	13 .98	13 .01	−12 .2	0 .9	14 .1	...	...	...	...
	1054	−22 .1	14 .27	13 .30	−16 .9	− 3 .8	10 .0				
	1054	−23 .9	14 .77	13 .80	−14 .8	− 1.1	13.1				
	1055	−14 .0	14 .62	13 .65	−24 .9	11 .7	2 .7				
	1056	−10 .2	14 .82	13 .85	−25 .1	−11 .5	2 .9				
	1057	− 8 .6	14 .92	13 .95	−27 .6	−13 .7	0 .6				...
	1058	−15 .5	14 .13	13 .16	−28 .4	−15 .2	− 1 .8				
	1059	−17 .2	14 .27	13 .30	−29 .4	−16.0	− 2 .5				
	1060	−17 .3	13 .72	13 .55	−31 .5	−18 .3	− 4 .1				...
	1061	−11 .7	14 .60	13 .63	−32 .0	−18 .4	− 4 .5				
	1062	−10 .5	14 .62	13 .65	−33 .8	−20 .7	− 6 .2				
	1063	−12 .5	13 .72	13 .55	−35 .4	−22 .7	− 8 .6				
	1064	−15 .2	15 .56	14 .59	−36 .6	−22 .7	− 7.1				
	1065	− 8 .3	14 .67	13 .70	−31 .3	−17 .8	− 3 .6	...	...	...	...
	1066	2 .6	14 .32	13 .35	6 .1	19 .4					
1182	1067	20 .8	14 .83	13 .86	−35 .7	−21 .5					
Aug. 12, '04	1067	11 .2	14 .72	13 .75	32 .4	46 .5					
8h41m	1068	8 .9	14 .14	13 .17	25 .0	38 .5					
	1069	16 .7	13 .75	12 .78	24 .0	37 .1				...	...
	1070	14 .6	13 .23	13 .26	6 .3	19 .9					
	1071	20 .7	13 .13	13 .15	3 .8	12 .6					
	1072	22 .3	13 .26	12 .29	1 .9	26 .2					
	1073	−17 .0	14 .63	13 .66	2 .1	37 .5					
	1074	−18 .8	14 .53	13 .56	28 .0	41 .9					
	1075	−22 .3	14 .01	13 .07	26 .5	39 .9					
	1076	−16 .3	14 .63	13 .66	− 6 .1	7 .9					
	1077	−19 .6	13 .20	13 .16	7 .8	6 .0					
	1078	−13 .4	12 .87	11 .90	−41 .0	28 .8					
	1079	−11 .5	14 .23	13 .07	−44 .2	−30 .8					
	1080	−23 .3	13 .77	12 .78	−23 .5	−10 .8					
	1081	− 7 .2	13 .16	12 .19	3 .1	15 .7					

TABLE I *Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1187 Aug. 13, '04 9^h17^m											
1207 Aug. 23, '04 8^h59^m	1084	8°7	14°65	13°68	7°0	20°3	33°9	48°0			
	1085	11.5	14.10	13 13	4.9	17.5	31.0				
	1086	11 3	14.35	13 38	2.0	15.4	29.0	42.0			
	1088	20.4	14.60	13.63	8.5	21.9	35.6				
	1089	18 6	14.95	13.98	5.3	18.3	32.4	47.1			
	1090	20.9	13.98	13.01	3.9	17.2	30.4	42.8			
	1091	18.8	14.50	13.53	1.3	14.9	28.5	41.8			
	1092	22.8	14.02	13.05	0.1	13.4	26.4	39.2			
	1093	21.1	14.28	13.31	− 7.6	5.1	18.6	32.2			
	1094	20 1	14.34	13.37	− 9.8	3.4	16.9	30.2			
	1095	19.6	14.02	13.05	−14.1	− 1.5	11.5	25.0			
	1096	22.1	14.88	13.91	−16.6	− 3.1					
	1097	11.7	14.80	13.83	−15.9	− 2.0	11.6				
	1098	12.1	14.47	13.50	−18.9	− 5.8					
	1099	16.0	14.36	13.39	−20.2	− 7.2					
	1100	18.3	13.89	12.92	−24.0	−11.2	1.7	14.7			
	1101	9.5	14.87	13.90	−21.2	− 7.3	9.7	19.4			
	1102	11.5	14.11	13.14	−25.0	−12.2	1.1	14.3			
	1103	14.7	14.30	13.33	−25.8	−12.9	0.8	14.0			
	1104	−23.0	14.88	13.91	−17.0	− 3.5					
	1105	−23.6	13.90	12 93	−20.6	− 7.4	4.7	18.4			
	1106	−25.5	13.59	12.62	−22.0	− 8.6	3.1				
	1107	−22.1	14.11	13.14	−24.9	−12.0	1.0	14.5			
	1108	−27.3	13.68	12.71	−28.1	−15.0	− 2.1	9.9			
	1109	−24.2	13.99	13.02	−28.5	−16.0	− 2.7	10.4			
	1110	−27.1	13.95	12.98	−32.0	−19.4					
	1111	−16.1	13.64	12.67	30.7	43.0					
	1112	−17.7	14.69	13.72	−37.3	−24.1	−10.7	3.9			
	1113	−14.8	14.48	13.51	−35.3	−22.0	− 8.3	5.0			
	1114	−12.9	13.95	12.98	−35.7	−22.9	− 9.9				
	1115	28.0	14.15	13.18	−22.8	−10.0					
	1116	32.0	14.36	13.39	−27.7	−14.7					
	1117	30.5	14.47	13.50	−26.0	−12.9					
	1118	33.9	14.77	13.80	−29.9	−16.5					
	1119	37.1	14.05	13.08	−28.1	−15.4					
	1120	−18.5	14.03	13.06	−44.1	−31.0	−17.9	− 5.0			
	1121	−20.1	14.54	13.57	−42.1	−29.2	−15.5	− 1.5			
	1122	−23.1	13.87	12.90	−42.8	−30.0	−17.0	− 4.2			
1218 Aug. 24, '04 8^h16^m5	1123	16.4	13.94	12.97	5.9	19.1					
	1124	16.4	13.45	12.48	− 6.0	6.7					
	1125	27.5	13.85	12.88	−11.8	1.0	14.2				
	1126	10.9	14.40	13.43	18.0	31.8	45.1				
	1127	33.5	13.26	12.29	−22.8	−10.4	2.0				
	1128	36.4	12.62	11.65	−23.5	−11.7	0.0				
	1130	15.7	14.50	13.53	−42.3	−28.6	−15.0				
	1131	23.9	13.94	12.97	−38.8	−25.6					
	1132	− 5.7	15.03	14.06	−16.3	− 2.0					
1234 Aug. 25, '04 8^h41^m5	1133	18.7	14.47	13.50	13.5	27.0					
	1134	24.0	13.57	12.60	16.4	29.0					
	1135	11.4	14.87	13.90	8.9	22.8					
	1136	13.1	14.07	13.10	6.9	20.0					
	1137	14.2	14.37	13.40	4.8	18.2					
	1138	23.8	13.97	13.00	4.1	17.1					
	1139	32.0	13.27	12.30	− 0.9	11.4					
	1140	35.9	12.37	11.40	−15.5	− 4.1					
	1141	40.1	11.47	10.50	−19.2	− 8.7					
	1142	−17.6	14.67	13.70	−23.2	− 9.5					
	1143	−22.1	14.27	13.30	−27.4	−14.1					
	1144	−21.4	14.77	13.80	−31.7	−17.9					
	1146	−13.7	14.77	13.80	−35.1	−21.3					
	1147	−14.4	14.37	13.40	−39.5	−26.1					
	1148	9.3	14.77	13.80	−42.0	−28.2					

TABLE I—Continued

Epoch, Number, and Date	Number	Latitude	Period, Meteor: Sidereal	Synodic	Longitudes on Days of Observation: 1	2	3	4	5	6	7
[illegible]	1149	[illegible]	[illegible]	[illegible]	−40°9	−27°5					
	1150	14 9	13.87	12.90	−44 5	−31 6					
	1151	11 2	14.47	[illegible]	−45 1	−31.6					
	1152	13 3	[illegible]	13 40	−47.5	−34.1					
	1153	−21.7	13 87	12.90	−13 0	− 0 1					
	1154	−21.4	12.57	11.60	− 8.0	3.6					
1241 Aug. 26, '04 8h42m											
1242 Sept. 9, '04 11h53m	1155	28 6	14.73	13.75	5.1	18 2					
	1156	−26 6	[illegible]	[illegible]	0 9	13 9					
	1157	[illegible]	[illegible]	[illegible]	− 2.1	9.8					
	1158	[illegible]	14.10	13.12	0 0	12.5					
	1159	[illegible]	14 20	13.22	− 2.6	10.0					
	1160	[illegible]	14 84	13.86	− 9.4	3.8					
	1161	−18.7	14.73	13.75	− 5.3	7.8					
	1162	−13.1	[illegible]	12 91	13.5	25.8					
	1163	−21.5	12.74	11.76	23 9	35.1					
	1164	−10 4	14 84	13.86	24.1	37.3					
	1165	[illegible]	14 20	13.22	29 3	41.9					
	1166	−10 6	13 78	12.80	30.8	43.0					
	1167	−12 1	14.73	13.75	6 0	19.1					
	1168	−10 4	15.04	14.06	7.4	20.8					
	1169	−17.1	14.42	13.44	2.5	15.3					
	1170	12 4	[illegible]	14.59	28.0	41 9					
	1171	17.7	14 52	13.54	30.0	42.9					
	1172	19 9	13 78	12.80	33.8	46.0					
	1173	17.7	13.99	13.01	33.6	46.0					
	1174	13 9	14.52	13.54	33.9	46.8					
	1175	17.8	14.52	13.54	21.3	34.2					
	1176	19 8	14 63	13.65	20.5	33.5					
	1177	17 9	13.47	12 49	15.2	27.1					
	1178	16 9	14.20	13.22	11.7	24 3					
	1179	− 3.3	13.99	13.01	23.8	36.2					
	1180	[illegible]	14 52	13 54	−15.1	− 2.2					
	1181	[illegible]	[illegible]	[illegible]	−29.5	−16.9					
	1182	[illegible]	14.42	13.44	−31.8	−19.0					
	1183	−32.3	[illegible]	[illegible]	−35 0	−22.3					
	1184	−28 5	[illegible]	[illegible]	−38 9	−25.6					
	1185	−28 3	13 99	13 01	−36 0	−23.6					
	1186	− 7 0	16 09	15.11	−38 2	−23 8					
	1187	24 4	15.78	14 80	32 4	46 5					
	1188	26 5	13.78	12 80	27.8	40 0					
1270 Sept. 10, '04 9h27m											
1294 [illegible]	1193	11 9	14 52	13 53	[illegible]		− 8°3		20 1		
	1194	−18 5	[illegible]	[illegible]	[illegible]		39 7				
	1195	[illegible]	14 10	13 11	12 3		37 3				
	1196	[illegible]	[illegible]	[illegible]	−29.8		− 5 2				
	1197	30 7	[illegible]	12 22	25 0		[illegible]				
	1198	[illegible]	[illegible]	12 59	22 7		46 7				
	1199	20 9	[illegible]	[illegible]	20 2		48 9				
	1200	−20 0	[illegible]	13 46	16 5		42 1				
	1201	−20 5	[illegible]	[illegible]	20 4		45 7				
	1202	14 2	[illegible]	12 75	−45.6		−21 3				
	1203	−17.3	[illegible]	[illegible]	[illegible]		17 9				
1295 [illegible]	1204	−26 8	[illegible]	[illegible]	−29 6		4 8				
	1205	−14 4	14 95	[illegible]	[illegible]		2 1				
	1206	−26 4	13 79	[illegible]	−27 1		4 0				
	1207	[illegible]	14 83	[illegible]	[illegible]		3.1				

TABLE I *Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1295 (*cont.*)	1205	−26°3	13°88	12 89	−32°3		− 6°0				
	1206	−24.5	13.83	12.84	−34.2		− 8.0				
	1207	14.6	14.02	13.03	−35.5		− 8.9				
	1208	16.4	12.90	11.91	−37.8		−13.5				
	1209	19.2	13.44	12.45	−40.5		−15.1				
1301 Oct. 3, '04 10h11m											
1311 Oct. 6, '04 9h39m	1211	14.2	14.65	13.66	30 2	43 8					
	1212	15.5	14.35	13 36	31.8	45.1					
	1213	16.2	14.45	13.46	29 9	43.3					
	1214	18.4	14.45	13.46	32 0	45.4					
	1215	17.6	15.05	14.06	27.9	41.9					
	1216	18.9	15.65	14.66	25.3	39.9					
	1217	16.8	13.84	12.85	25.3	38.1					
	1218	19.3	13.84	12.85	24.0	36.8					
	1219	21.1	14.65	13.66	25.8	39.4					
	1220	21.6	14.75	13.76	21.2	34 9					
	1221	16.1	15.75	14.76	16.5	31.2					
	1222	21.8	14.35	13.36	7.9	21.2					
	1223	−19.4	14.55	13.56	29 0	42.5					
	1224	−16.9	14.15	13.16	31.2	44.3					
	1225	−16.5	13.64	12.65	15.1	27.7					
	1226	−15.1	15.05	14.06	16.4	30.4					
	1227	−18.1	13.74	12.75	18.0	30.7					
	1228	−20.9	14.75	13.76	14.0	27.7					
	1229	−22.3	14.35	13.36	11.5	24.8					
	1230	−14.7	13.84	12.85	13.7	26.5					
	1231	−22.5	14.15	13.16	4.7	17.8					
	1232	−20.5	13.34	12.35	4.5	16.8					
	1233	−23.5	13.14	12.15	0 0	12.1					
	1234	25.2	14.75	13.76	− 9.2	4.5					
	1235	22 7	14.35	13.36	− 6.0	7.3					
	1236	20 8	13.44	12.45	−14.7	− 2.3					
	1237	25.4	14.45	13.46	−15.9	− 2.5					
	1238	− 9.0	14.35	13.36	7.6	20.9					
	1239	21.3	13.84	12 85	−10.8	2.0					
	1240	17.4	14.35	13.36	7.9	21.2					
	1241	−15.1	13.24	12.25	− 4.2	8 0					
	1242	−12.8	14.95	13.96	− 2.0	11.9					
	1243	−17.2	15.05	14.06	−11.4	2.6					
1314 Oct. 7, '04 9h33m											
1318 Oct. 15, '04 9h22m	1245	13.8	13.69	12.70	18.5		44.1				
	1246	19.1	14.43	13.44	− 4.8		22.3				
	1247	17.4	14.27	13.28	− 8.3		18.5				
	1248	24.0	14.31	13.32	−11.1		16.3	29°0			
	1249	22.8	14.33	13.34	−13.7		13.5	26.5			
	1250	13.0	14.53	13.54	−20.5		6.4	20.5			
	1251	15.6	13.94	12.95	−22.1		4.1	17 0			
	1252	17.1	14.08	13.09	−20.1		6.0	19.5			
	1253	18.9	14.11	13.12	−19.7		6.8	19.9			
	1254	18.0	14.33	13.34	−36.1		− 9.2				
	1255	21.2	14.01	13.02	−24.2		2.1	15.1			
	1256	−24.7	14.98	13.99	− 4.9		21.9	37.7			
	1257	−21.2	14.56	13.57	− 9.1		18.2	31.9			
	1258	−17.2	14.07	13.08	−12.0		13 9	27 6			
	1259	−17.3	14.16	13.17	−15.5		11.0	24.3			
	1260	−19.8	14.07	13.08	−19.3		6.7	20.3			
	1261	−24.5	13.99	13.00	−26.6		− 0.1	12.6			
	1262	−24.0	14.19	13.20	−29.8		− 2.6	9 9			

TABLE I (*Continued*)

Group Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1318 (*cont.*)	[illegible]	−18°8	14°34	13°35	37 1		− 7°8	5°1			
	1264	−20 5	14.40	13 41	−36 0		− 9.2	4.6			
	1265	−25 8	14 24	13 25	−40 0		−13 3	0 0			
1324	1266	−22 6	14 05	13 06	1.1	14°2					
Oct. 17, '04	1267	−25 7	14 85	13 86	1 2	15.1					
	1268	−24.8	16 35	15 36	19 4	34.8					
	1269	−24 4	15 75	14 76	17.0	31.8					
	1270	25.2	13 85	12 86	− 5.9	7.0					
	1271	25 0	13 95	12 96	−10.7	2.3					
	1272	17 6	13 95	12 96	−18.5	− 5.5					
	1273	18 2	14 95	13 96	−23.1	− 9.1					
	1275	−30 0	14 25	13 26	−13 8	− 0.5					
	1276	−28 2	13 85	12 86	−16 0	− 3.1					
	1277	−33.8	14 25	13 26	−16.1	− 2.8					
	1278	−33.0	14.05	13 06	−17.9	− 4.8					
	1279	27 9	14.65	13 66	−22.8	− 9.1					
	1280	−22 3	15 65	14.66	−26 9	−12.2					
	1281	−21 3	14.65	13.66	−22.2	8 5					
	1282	−18 3	14.95	13 96	29 7	−15.7					
	1283	−13 8	13 85	12 86	−24.0	−11.1					
	1284	−22 9	14 65	13 66	−34.6	−20.9					
	1285	−20 0	14 25	13.26	−38.0	−24.7					
	1286	−23 7	13 55	12 56	−39.2	−26.6					
1329											
Oct. 18, '04											
1336	1287	−18.9	14 47	13 47	31.0	44.3					
Oct. 26, '04	1288	−15 0	15 06	14.06	31.4	40.6					
	1289	−16.3	14.27	13 27	20.1	33.5					
	1290	−22 8	14.47	13 47	21.3	34.9					
	1291	−24.7	13 59	12 59	20.3	32.9	45.5				
	1292	−25.5	13 94	12 94	18.2	31.0	44.1				
	1293	−28 8	13.44	12.44	22.2	34.6	47.1				
	1294	−22 8	14 03	13 03	12.1	24 9	38.2				
	1295	−22 9	14 08	13 08	9.3	22.0	35.5				
	1296	−26 1	13 74	12 74	8.4	21.8	30 9				
	1297	27 9	14 27	13 27	5 1	18.5					
	1298	−26 8	14.43	13 43	2.1	15.0	28.9	42 3			
	1299	−28 0	14 03	13 03	− 0.8	11 1	24.2	37.1			
	1300	−22.7	14.18	13 18	− 1 0	11.3					
	1301	−16 4	14 02	13 02	9 6	21.1	35.4				
	1302	23 1	14 07	13 07	12 9	26.0					
	1303	−17 1	15 59	14 59	15 .	29.7					
	1304	−33 0	14 97	13 97	−11.1	2 6					
	1305	34 0	14 79	13 79	15 6	29 9	43 2				
	1306	15 1	14.74	13.74	19 8	34.1	47.3				
	1307	31 4	13 84	12 84	15.5	28 3	41.2				
	1308	−30 8	13 74	12.74	−15 3	− 2.6	10 2				
	1309	34 2	14 09	13 09	18 9	32 0	45.1				
	1310	33 1	14 97	13 97	15 8	36 9					
	1311	29 1	14 07	13 07	8 4	21 5					
	1312	36 4	14 42	13 43	14 5	24 3	36 0	48.7			
	1313	32 7	14 05	13 05	5 9	18 5	30 2	42 2			
	1314	40 9	12 88	11 88	8 6	20 6					
	1315	47 5	11 70	10 70	18 2	29 0					
	1316	45 7	11 89	10 89	22 5	33 5					
	1317	31 8	13 17	12 17	0 9	13 6	25 3	37 6			
	1318	7 1	15 16	14 16	0 8	15.1					
	1319	7 3	13 97	12 97	1 9	12 1					
	1320	13 8	14 29	13 29	−12 7	0 5	13 5	27 3			
	1321	11 0	14 23	13 23	−10 5	3 2	16 0				
	1322	9 A	14 09	13 09	8 1	18 6	31 6				
	1323	20 0	14 88	13 44	6 9	19 0	31 9				
	1324	11 7	14 24	13 24	−28 4	−14 7	− 1 .	11 3			

TABLE I—*Continued*

PLATE NUMBER AND DATE	NUMBER	LATITUDE	DIURNAL MOTION		LONGITUDES—DAYS—CM.						
			Sidereal	Synodic	1	2	3	4	5	6	7
1336 (*cont.*)	1326	8°2	15°06	14 06	−25°9	11 7					
	1327	8.1	15.26	14.06	−30.6	−16 2					
	1328	3.7	14.79	13.79	22.2	37.2	49 8				
	1329	10.9	14.56	13.56	−11.6	1.8	15.5	29.1			
1344	1330	−29.4	14.10	13.10	7.2	20.2					
Oct. 27, '04	1331	35.9	12.19	11.19	26.9	38.0					
9h55m	1332	9.4	13.77	12.77	12.2	24.2	37.7				
	1334	−24.0	13.42	12.42	−36 7	−24.9	−11.9				
	1335	−24.6	13.82	12.82	−42.5	−29.8	−16.9				
	1336	12.6	13.97	12 97	−41.1	−28.1	−15 2				
	1337	12.7	11 27	13.27	−37.9	−24.7	−11.4				
	1338	38.5	13 30	12.30	− 8.0	4.2					
	1339	32 5	11.98	10 98	−19.3	− 8.4					
	1340	10.2	14.17	13.17	21.5	34.4	47.8				
1348	1333	−31.0	13.35	12.35	−22 5	−10.1					
Oct. 28, '04	1341	8.5	14.64	13.64	28.2	41.9					
9h44m	1342	12.8	14.24	13.24	− 8.9	4.4					
	1344	20.9	13.95	12.95	−26.0	−13.0					
	1345	18.0	13.85	12.85	−11.1	1.8					
	1346	−14.0	14.32	13.32	−36.5	−23.1			17°0	30 5	43°0
	1347	−10.6	15.24	14.24	−40.2	−25.9					
	1348	13.9	14 26	13.26	−38.3	−25.2			14.6	28.0	41.0
	1349	10.1	14.20	13 20	10 7	−26.9			13.1	26.1	38.0
	1350	14.9	14.55	13.55	−41.2	−27.7			13.2	26.5	39.9
	1351	18.6	13.65	12.65	−40.9	−28.2					
	1352	−33.8	13.45	12.45	19.4	31.9					
	1353	−38.2	12.05	11.05	2.1	13.2					
	1354	8.0	13.05	12.05	18.1	30.2					
1354	1355	−17.4	14.26	13.26	−38.6			1.9	15.0		
Oct. 29, '04	1356	12.3	14.40	13.40	−30.4			9.9	23.5	36.2	
9h50m	1357	17.3	14.15	13.15	−37.5			2.5	15.7		
	1358	17.1	14.37	13.37	−34.9			4.6	17.9	31.5	45.3
	1359	21.9	13.94	12.94	−45.1			− 6.0	6.2	19.8	33.7
	1360	22.4	14.15	13.15	−43.8			− 4.4	8.9		
1362	1361	19.9	14.08	13.08	3.9	16.5	29.5	42.9			
Nov. 1, '04	1362	22.2	14.52	13.52	7.0	20.5	33.7				
10h00m	1363	25.0	13.44	12.44	7.7	20.1					
	1364	20.2	12.64	11 64	11.5	23.1					
	1365	23.7	15.08	14.08	13.1	27.1	40.9				
	1366	18.2	14.46	13.46	− 0.4	12.9	26.1	39.8			
	1367	17.3	14.11	13.11	− 4.0	9.0	21.7	35.2			
	1368	19.4	14.26	13.26	− 2.0	10.7	23.7	37.6			
	1369	21.2	13.74	12.74	− 1.6	11.1					
	1370	17.3	14.52	13.52	− 6.9	5.4	19.8				
	1371	22.6	14.21	13.21	− 9.0	3.8	16.9	30.4			
	1372	23.3	13.81	12 81	−11.1	1.8	14.2				
	1373	25.9	13.76	12.76	− 9.2	3.7	16 3	28.9			
	1374	−18.8	14.26	13.26	− 2.2	11.0	24.0	37.4			
	1375	−13.2	14.45	13.45	− 1.8	11.6					
	1376	−12.8	14.45	13.45	− 9.2	3.9	17.0	31.0			
	1377	−15.8	14.17	13.17	−15.7	− 2.5	10.2	23.7			
	1378	−17.5	14.53	13.53	−18.9	− 5.6	7.7	21.5			
	1379	−19.3	14.41	13.41	−17.0	− 3.5	9 5	23.1			
	1380	−17.7	14.80	13.80	−12.7	.0.0	14.2	28.7			
	1381	−20.5	14.32	13.32	−12.3	1.4	14.0				
	1382	−19.2	14.53	13.53	− 9.9	3.6	16.6	30.6			
	1383	−21.5	14.26	13.26	−18.0	− 4.6	8.1	21.7			
	1384	−20.6	14.10	13.10	−24.1	−10.9	1.7	15.1			
	1385	28.4	13.66	12.66	−32.5	−20.1	− 7.3	5.2			
	1386	25.3	13.84	12.84	−29.5	−16.7					
	1387	24.2	14.21	13.21	−33.0	−19.9	− 7.4	6.6			
	1388	22.9	13.62	12.62	−37.5	−24.9	−11.9	0.0			
	1389	21.3	14.33	13.33	−29.9	−17.4	− 4.0	9.8			
	1390	20.2	13.84	12.84	−30 8	−18.0					
	1391	24.6	14.29	13.29	−25.7	−13.3	0.0	13.9			

TABLE I—(Continued)

Planet Number and Date	Number	Latitude	Diurnal Motion		Differences, Dates of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1366	[illegible]	7°6	14°59	13°31	−32°5	−20°0	− 6°0				
Nov. 2, 04	[illegible]	−19 4	14 19	13.19	−32 9	−20 0					
[illegible]	1394	−15 4	14 36	13 36	3 5	16.1	30 1				
1370	[illegible]	17 7	14 51	13 51	28 2	41 9					
Nov. 3, 04	[illegible]	18 2	14 12	13.12	30 2	43.5					
[illegible]	1397	19 2	14 12	13.12	19 9	33 2					
[illegible]	[illegible]	−20 4	14 51	13 51	18 2	31 9					
	1400	−20 0	14 22	13 22	27 2	40 6					
	1401	−16 9	14 51	13 51	11.5	25.2					
	[illegible]	9[illegible]8	14 61	13 61	4.7	18.5					
	1404	−23 8	14 12	13 12	9 4	22 7					
	[illegible]	−26 1	14 61	13 61	22.1	35.9					
	[illegible]	−16 0	14 [illegible]2	13 32	−44.3	−30 8					
	[illegible]	−13 [illegible]	15 30	14 30	−46 7	−32.1					
	[illegible]	− 7.1	14 91	13 91	−49 5	−35.4					
	1409	9 8	14 81	15 81	−25 8	−11 8					
	1410	11 1	14 61	13 61	−31.5	−18.0					
	1411	17.1	14 41	13 41	−48 6	−35.0					
	[illegible]	15.3	14 81	13 81	− 3 1	10 9					
	1413	23 6	14 12	13 12	1.7	15 0					
	1414	12 3	13 53	12 53	25 3	38.0					
[illegible]											
Nov. 4, 04											
[illegible]											
[illegible]	[illegible]	19 3	[illegible] 84	12 84	20 9		46.0				
Nov. 14, 04	1416	12 4	13 27	12 26	−15.1		39.1				
[illegible]	1417	14 9	[illegible] 04	13 03	7.1		32 6				
	1418	25 3	14 45	13 44	− 0 8		25 5				
	1419	17 2	15 06	14 05	− 3.7		25 8				
	[illegible]	16 6	14 81	13 80	− 5.3		21 7				
	1421	[illegible] 1	13 99	12 98	− 9.1		16 3				
	[illegible]	18 8	14 55	[illegible] 54	− 7.7		18 8				
	1423	[illegible] 1	14 19	[illegible] 18	6 0		31.8				
	1424	24 0	13 58	12 57	4 9		29 5				
	[illegible]	−39 9	13 12	12 11	15 1		38 8				
	1426	−15 1	14 50	13 49	−32 9		− 6.5				
	1427	−20 7	14 55	13 54	−40 5		−14 0				
	[illegible]	−18 4	13 94	12 93	−39 1		−13 8				
	1429	−17 2	14 40	13 39	−45 2		−19 0				
	1430	−12 1	[illegible] 89	12 88	−43 2		−18 0				
	1431	−15 7	14 76	13 75	−47 7		−20 8				
	1433	[illegible] 1	14 55	13 54	−34 5		− 8 0				
	1434	17 5	[illegible] 04	13 03	−11 4		14 1				
	1435	−23 8	14 24	13 23	0 4		26 3				
1436											
Nov. 14, 04											
[illegible]											
[illegible]	[illegible]	[illegible] 3	14 18	13 17	[illegible] 6	43 2					
[illegible] 04	1437	9[illegible] 8	13 99	12 98	22 2	36 2					
[illegible]	[illegible]	15 1	14 18	13 17	27 7	41 9					
	1439	[illegible] 3	13 90	12 89	19 4	33 3					
	[illegible]	8 6	14 45	13 44	16 9	31 4					
	1441	5 7	14 27	[illegible] 26	15 2	[illegible] 5					
	1442	[illegible] 8	14 18	13 17	16 4	30.6					
	[illegible]	11 4	[illegible] 27	13 26	14 5	[illegible] 8					
	1444	[illegible] 0	13 81	12 80	[illegible] 8	29 7					
	[illegible]	10 9	14 18	13 17	[illegible] 3	22 7					
	1446	[illegible] 0	14 08	[illegible] 07	[illegible] 8	19 9					
	[illegible]	[illegible] 4	[illegible] 36	[illegible] 35	3 4	[illegible] 0					
	1448	[illegible] 4	[illegible] 13	[illegible] 12	5 1	19 9					
	[illegible]	20 3	[illegible] 08	13 07	[illegible] 7	[illegible] 8					

TABLE I—*Continued*

PLATE NUMBER AND DATE	NUMBER	LATITUDE	DIURNAL MOTION		LONGITUDES ON DAYS OF OBSERVATION						
			Sidereal	Synodic	1	2	3	4	5	6	7
1404 (*cont.*)	1450	12°2	13°81	12°80	0°3	14°1					
	1452	7.9	14.18	13 17	− 0.3	13 9					
	1453	9 8	13.99	12.98	0 1	14.1					
	1454	10 2	13.16	12 15	2 6	10.5					
	1455	5.5	13.62	12 61	− 1.0	12.6					
	1456	−17.8	13.25	12.24	27.1	40 3					
	1457	−18.5	14.36	13.35	21 8	39 2					
	1458	−16.9	14.45	13 44	23.0	37.5					
	1459	18.9	13.81	12 80	−24.1	−10.3					
	1460	21.5	12.88	11.87	−24.4	−11.6					
	1461	19.6	14 55	13.54	−27.2	−12 6					
	1462	17.8	14.45	13 44	−35 2	−20.7					
	1463	17.5	13.62	12 61	−42.5	−28.9					
	1464	−21.1	13.81	12.80	−40 3	−26.5					
	1465	−17.0	13 53	12 52	−18.5	− 5.0					
	1466	−15.1	14.08	13.07	−14.0	0.1					
	1467	− 2 8	15.29	14.28	−17.2	− 1.8					
	1468	−25.4	13.81	12.80	−13.8	0.0					
1408 Nov. 23, '04 11h36m											
1419 Dec. 13, '04 10h24m	1534	12.6	14.15	13.14	21 8	35.1					
	1535	7.7	14.64	13.63	22.8	36.6					
	1536	9.9	14 64	13 63	28.1	41.9					
	1537	9.7	14.64	13.63	30.6	44 4					
	1540	14.6	14.45	13 44	25.3	38 9					
	1541	16.1	14.74	13.73	24.0	37.9					
	1542	19.1	14.25	13.24	26 6	40.0					
	1543	18.6	13.83	12.82	23.2	36.5	49.2				
	1544	12.5	13.58	12.57	8.7	21.8	34.2				
	1545	13.0	13.76	12.75	6.6	19.5					
	1546	15.8	14.28	13.27	7.3	21.2	34.2				
	1547	12 3	14.13	13.12	− 0.2	13.2	26.4				
	1548	15 7	14.15	13.14	1.0	14.3					
	1549	13.3	14.64	13.63	− 2.7	11.1					
	1550	15 0	14.64	13.63	− 6.4	7.4					
	1551	23.5	15.14	14.13	− 4.4	9.9					
	1552	22.0	13.95	12.94	28.1	41.2					
	1553	30.5	12.80	11.79	25.2	37.0	49 1				
	1554	33.8	13.56	12 55	21.0	33.7					
	1555	20.5	14.25	13.24	1.9	15.3					
	1556	12.3	13.66	12.65	− 6.9	5.9					
	1557	12.7	14.55	13 54	− 9.8	3.9					
	1558	10.1	14.64	13.63	− 9.9	3.9					
	1559	14 5	14.11	13.10	−15.6	− 2.1	11.5		37°3		
	1560	14.3	14.82	13.81	−18.0	− 4.1	10.0				
	1561	12.2	14.13	13.12	−18.6	− 5.1	8.2		34.4		
	1562	11.2	14.08	13.07	−19.4	− 6.2	7.1				
	1563	15.3	14.45	13.44	−21.9	− 8.3					
	1564	20.5	13.53	12.52	−26.1	−13.7	− 0.7				
	1565	13.5	14.37	13.36	−23.5	−10.1	3.6				
	1566	16.3	14.17	13.16	−25.0	−12.1	1.4		28.0		
	1567	17.5	13.53	12.52	−27.8	−15.2	− 2.4				
	1568	21.8	13.88	12.87	−32.9	−20.0	− 6.8				
	1569	18.0	13.85	12.84	−36.9	−23.9					
	1570	17.8	13.93	12 92	−39.5	−27.5	−13.3				
	1571	−34.5	13.76	12.75	26.0	38.9					
	1573	−11.9	14 55	13.54	8.3	22.0					
	1574	−15.2	14.62	13.61	8.4	22.0	36.0				
	1575	−16.1	13.98	12 97	2.2	15.3	28.5				
	1576	−24:9	14.10	13.09	5 0	8.2	21.7		47.8		
	1577	−29.5	12.96	11.95	−13.1	− 1.0					
	1578	−22.9	14.08	13.07	−16.2	− 3.5	10.3				
	1579	−27.2	13.24	12.23	−17.1	− 4.8	8.9		32.1		
	1580	−33.3	13.38	12.37	−16.2	− 3.5	9.6		33.7		
	1581	−31.3	13.73	12.72	−21.9	− 9.2	3.9				

TABLE I—*Continued*

Number and Date	Number	Observed	Observed Motion		Computed Motion		Residuals in Decimals of Observation				
			Sidereal	Synodic	1	2	3	4	5	6	7
1428	1582	-28°0	15 18	12°15	-21.2	− 8°9					
	1583	-27 9	12 94	11 90	-25 1	−12 9	− 0°9				
	1584	-14 5	14 25	13 24	-31 0	−17.6					
	1585	-13 6	14 74	13 73	-34 0	−20 1					
	1586	2 9	14 94	15 93	-39 8	−25.7					
	1587	5 0	15 26	14.25	-42 4	−28 2	−13 5				
	1588	15 8	14 37	13 36	- 1.8	11.7	25.3				
	1589	13 9	13 95	12 94	0 9	14.0					
1429	1590	16 4	14 01	13 00	18 0	31.2					
Dec. 14, '04	1591	-17.5	14 60	13 59	17.2	31.0					
(1904.9)	1592	-21.7	14 79	13.78	18 2	32 2					
	1593	-26 2	14 30	13 29	15.5	29.0					
	1594	-29 2	14 11	13.10	15.9	29.2					
	1595	-30 8	14 01	13 00	4 2	17.4					
	1596	24 9	15 93	12 94	-24.9	−11.3.		14°3			
	1597	-25 2	14 01	13 00	10 8	24.0					
	1598	11 2	14 29	13 28	-16 9	− 3.2		23 3			
	1599	-11 0	15 99	15 98	-38 2	−24 0					
	1600	12 8	14 70	13.69	-20 0	− 6.1					
	1601	15 3	15 32	12 41	-23 2	−10 6					
	1602	24 3	13 91	12 90	-28.9	−15 3		10 2			
	1603	8 9	14.50	13 49	-34 8	−21.1					
	1604	3 5	14 30	13 29	-43 4	−29.9					
1429	1605	25 6	14 01	13 00	-13 6		12 5				
Dec. 15, '04	1606	24 1	15 26	12 25	-29 8		- 5.2				
(1904.9)	1607	25 5	15 86	12 85	-30 8		- 5 0				
	1608	16 4	15 09	12 59	-35.9		- 9.4		16°7		39 7
	1609	11 6	14 50	13 49	-42 2		-14.1		11.9		
	1610	-11 0	14 35	13.34	-32 9		- 6.1		20 5		47.5
	1611	16 7	14 41	13 40	3 9		30 8				
	1612	16 2	13 75	12 74	- 5.3		20 0		45 8		
	1613	13 2	13 86	12 85	- 8 2		17.6				
1432	1614	25 2	13 43	12 42	-11 2		13 2		38.7		
Dec. 17, '04	1614	20 9	13 10	12 09	-13 4		10 8				
(1904.9)	1615	-16 0	14 2	13 31	-13.0.		12 4		10 5		
	1616	-15 0	13 54	12 53	-16 2		8 9				
	1617	-19 7	14 44	13 43	-21 9		5.0				
	1618	-18 5	14 39	13 38	4.7		31.5				
	1619	31 7	13 59	12 58	- 7 9		17.3				
	1620	31 3	13 94	12 93	- 5.1		20 8				
	1621	12 2	14 19	13 18	-20 1		6 3				
	1622	11 6	13 79	12 78	-21 5		4.1				
	1624	21 4	14 09	13 08	15 8		42 0				
1438	1625	31 2	15 46	12 45	10 8		35 9				
Dec. 19, '04	1626	-12 6	14 25	13 24	18 8		45 5				
(1904.9)	1627	11 2	13 81	12 80	-13 8		12 0				
	1628	19 7	14 15	13 14	-14 9		11.6				
	1629	13 4	13 54	12 50	-13 0		12 2				
	1630	22 1	14 40	13 39	-29 1		- 2 7				
	1631	5 0	14 01	13 00	-34 3		- 8 1				
	1632	24 2	14 50	13 49	-37 6		-10 4				
	1633	17 3	14 40	13 39	-36 1		- 9.1				
	1634	11 6	14 35	13 34	-33 1		- 6 2				
	1635	13 5	14 40	13 39	-32 0		- 5 0				
	1636	16 0	14 01	13 00	-44 2		-18 0				
	1637	9 3	14 35	13 34	[illegible]		25 8				
	1638	12 6	14 55	13 54	- 3 1		24 2				
	1639	26 2	13 71	12 70	13 2		38 8				
	1641	26 3	13 86	12 85	[illegible]		47 4				
1440											
Dec. 20, '04											
(1904.9)											

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Dates of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1450	1641	20.5	13°54	12°53	31°0	43.6					
Dec. 30, '04	1642	18.3	14.63	13.62	25.0	38.7					
10^h42^m5	1643	17.0	13.73	12.72	30.3	43.1					
	1644	15.1	14.83	13.82	26.6	40.5					
	1645	12.0	14.33	13.32	30.1	43.5					
	1646	8.1	13.93	12.92	21.2	34.2					
	1647	21.7	13.24	12.23	5.0	17.3					
	1648	21.7	13.64	12.63	− 8.7	4.0					
	1649	17.3	14.23	13.22	−23.0	− 9.7					
	1650	−17.8	12.84	11.83	31.5	43.4					
	1655	−22.1	14.03	13.02	22.1	35.2					
	1656	−26.8	14.03	13.02	21.3	34.4					
	1657	−30.0	14.23	13.22	15.7	29.0					
	1658	− 6.1	14.23	13.22	8.0	21.3					
	1659	− 4.8	14.43	13.42	6.1	19.6					
	1660	−13.4	15.72	14.71	0.2	15.0					
	1661	−12.8	15.13	14.12	− 1.2	13.0					
	1662	−19.0	15.33	14.32	− 2.3	12.1					
	1663	−21.4	13.73	12.72	− 5.4	7.4					
	1664	−19.4	14.13	13.12	− 9.2	4.0					
	1665	−17.7	15.23	14.22	− 9.3	5.0					
	1666	−23.9	13.24	12.23	−12.7	− 0.4					
1453											
Dec. 31, '04											
10^h51^m											
1467	1667	15.3	14.65	13.63	31.2	44.4					
Jan. 12, '05	1668	17.3	14.34	13.32	27.6	40.5					
11^h39^m5	1669	12.4	15.17	14.15	24.3	38.0					
	1670	11.2	14.44	13.42	27.9	40.9					
	1671	7.5	14.60	13.58	14.3	27.1	41°0				
	1672	14.2	14.09	13.07	10.9		36.6				
	1673	15.5	13.84	12.82	8.8	20.9	34.0				
	1674	17.8	14.35	13.33	9.8	22.3	36.0				
	1675	18.4	14.45	13.43	6.1	18.8	32.5				
	1676	19.4	14.24	13.22	6.2	19.0					
	1677	20.1	14.13	13.11	4.6	17.3					
	1678	16.4	13.94	12.92	3.5	16.1	28.9				
	1679	13.0	14.24	13.22	3.2	16.4	29.2				
	1680	14.2	13.88	12.86	1.1	13.9	26.4				
	1681	15.3	14.04	13.02	− 1.3	10.9	24.3				
	1682	21.5	14.14	13.12	0.0	12.7	25.8				
	1683	18.9	14.75	13.73	− 2.9	10.4					
	1684	25.0	14.09	13.07	− 7.0	5.6	18.7				
	1685	27.0	13.99	12.97	− 7.0	5.5	18.5				
	1686	24.6	13.72	12.70	− 8.5	3.8					
	1687	27.5	13.48	12.46	− 9.0	2.9	15.5				
	1688	30.2	14.09	13.07	−13.9	− 0.9	11.8				
	1689	30.7	13.72	12.70	−17.0	− 4.7					
	1690	28.6	14.44	13.42	−19.1	− 6.1					
	1691	25.3	14.14	13.12	−15.8	− 2.8	10.0				
	1692	23.0	13.43	12.41	−13.2	− 1.2	11.2				
	1693	23.5	14.44	13.42	−11.7	1.3					
	1694	20.9	14.34	13.32	−13.0	− 0.1	13.2				
	1695	20.1	14.50	13.48	−17.4	− 4.0	9.1				
	1696	13.5	13.82	12.80	−24.4	−12.0					
	1697	20.7	13.84	12.82	−28.2	−15.7	− 3.0				
	1698	27.7	13.84	12.82	−31.0	−18.5	− 5.8				
	1699	5.0	13.99	12.97	−45.0	−32.4	−19.5				
	1700	7.1	14.03	13.01	−44.9	−32.3					
	1701	− 8.5	14.65	13.63	−18.3	− 4.6	8.5				
	1702	− 7.0	14.65	13.63	−15.1	− 1.9					
	1703	−20.6	14.75	13.73	−19.2	− 5.7	7.8				
	1704	−15.9	14.86	13.84	34.7	48.1					
	1705	−25.7	14.13	13.11	26.2	38.9					
	1706	−29.7	14.03	13.01	26.5	39.1					
	1708	−31.2	13.72	12.70	22.8	35.1					

TABLE I—*Continued*

Planet Number and Date	Number	Longitude	Diurnal Motion		Longitudes in Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1467	1709	−41°5	12°01	10°99	22°7	33°1	44°3				
	1710	−35 1	13 88	12 86	15 4	28 3	40 7				
	1711	−31 4	13 94	12 92	− 1.5	11 3	23 9				
	1712	−32 7	13 28	12 26	− 8 0	3.3	16 1				
	1713	−13 7	13 89	12 87	17.9	29.7	43.2				
	1714	−17 0	14 29	13 27	18 3	31.7	44 1				
	1715	−17 0	14 99	12 97	15 5	28 2	41.0				
	1716	−17 0	14 44	13.42	13.7	26.7					
	1717	−21 7	14 40	13 38	17.6		43 9				
	1718	−17 7	14.90	13.88	7.4	20 7	34.7				
1470 Jan. 15, '05 10h54m	1719	15 1	14 85	13 83	25 0	38.8					
	1720	21 3	13 75	12.73	22 2	34.9					
	1721	−17.7	14 85	13.83	− 7.8	6 0					
	1722	12 9	13.45	12.43	−42.1	−29.7					
	1723	18 2	13 65	12 63	−38.1	−25 5					
	1724	32 1	13 95	12 93	−26.9	−14 0					
	1725	34 9	13 95	12.93	−33.2	−20 3					
	1726	−29 2	13.55	12.53	0.5	13 0					
	1727	−20 0	13 75	12.73	−24.9	−12.2					
	1728	−22 0	13 75	12.73	−28 8	−16 1					
	1729	−17 0	13.15	12 13	−26.5	−14.4					
	1730	−21.2	14 15	13.13	− 9.1	4 0					
	1731	−15 8	14 15	13.13	−14.5	− 1.4					
1476 Jan. 14, '05 10h51m											
1516 Feb. 17, '05 10h51m	1737	8 2	14 69	13 68	21.8	35 5					
	1738	9 9	14 19	13.18	24.4	37.6					
	1739	10 5	14.09	13.08	22 9	36 0					
	1740	11 9	14 19	13.18	20 0	33 2					
	1741	7 8	14.39	13 38	15.3	28.7					
	1742	7 3	14.09	13.08	19 9	33.0					
	1743	−22 0	14.49	13 48	18.2	31.7					
	1744	−20 4	13 99	12 98	19.8	32 8					
	1745	−16 8	14.19	13.18	25.3	38.5					
	1746	−22 1	14.19	13.18	25.4	38.6					
	1747	−17.4	14.39	13 38	29 3	42 7					
	1748	−18 4	14.19	13 18	30 7	43.9					
	1749	−16 1	14 89	13 88	31.4	45.3					
	1750	−14 2	13 99	12 98	29 9	42 9					
	1751	−12 6	13 89	13 38	27.9	41.3					
	1752	9 3	14 49	13 48	21 3	34.8					
	1753	17 5	13 49	12 48	16 7	29.2					
	1754	21 5	14 49	13 48	18 7	32 2					
	1755	19 3	13 89	13 68	17 2	30 9					
	1756	18 2	13 39	12 38	16 1	28 5					
	1757	22 4	13 89	12 78	11.4	24.2					
	1758	22 1	13 49	12 48	16 2	28.7					
	1759	21 7	13 89	13 38	16 5	30 1					
	1760	21 9	13 09	12 08	2 0	14 1					
	1761	7 3	12 89	11 88	2 8	14 7					
	1762	14 2	14 39	13 38	−32 7	−19 3					
	1763	8 1	14 39	13 38	30 4	43 8					
	1764	8 3	14 49	13 48	31 9	45 4					
	1765	−20 9	13 09	13 08	−38 1	−25 0					
	1766	−25 5	12 59	11 58	−45 6	−34 0					
	1767	18 2	13 09	13 08	25 3	38 4					
	1768	−19 0	13 69	12 68	23 9	36 6					
	1769	8 3	14 99	13 98	27 2	41 2					
	1770	20 5	12 59	11 58	−45 0	−33 3					
	1771	14 4	13 79	12 78	18 2	31 0					
1503 Feb. 16, '05 10h54m											
1509 Feb. 20, '05 09h57m	1772	13 4	14 89	13 88	11 4	25 4					
	1773	−17 1	14 09	13 09	13 3	38 3					
	1774	−17 6	13 81	12 80	1 9	24 1					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1529 (*cont.*)	1775	−24°.4	13.52	12.51	−33°.7	−20°.8					
	1776	−21.1	14.39	13.38	−30.3	−16.5					
	1777	−19.9	15.07	14.06	−30.3	−15.8					
	1778	−18.0	14.39	13.38	−29.3	−15.5					
	1779	−16.1	14.39	13.38	−28.1	−14.3					
	1780	17.6	14.29	13.28	−25.7	−12.0					
	1781	−13.2	14.78	13.77	−27.3	−13.1					
	1782	−16.3	14.39	13.38	−29.9	−16.1					
	1783	−21.7	14.20	13.19	−26.6	−13.0					
	1784	−21.9	14.10	13.09	−22.4	− 8.9					
	1785	−18.6	14.78	13.77	−20.2	− 6.0					
	1786	−20.1	14.59	13.58	16.4	30.4					
	1787	−19.4	14.20	13.19	12.9	26.5					
	1788	−22.0	14.10	13.09	11.8	25.3					
	1789	−18.1	14.20	13.19	27.4	41.0					
	1790	4.0	14.39	13.38	28.3	42.1					
	1791	2.1	14.39	13.38	28.7	42.5					
	1792	1.4	13.71	12.70	27.1	40.2					
	1793	3.4	14.68	13.67	26.3	40.4					
	1794	9.9	14.68	13.67	24.9	39.0					
	1795	10.0	14.49	13.48	30.4	44.3					
	1796	5.3	14.39	13.38	29.3	43.1					
	1797	4.5	14.10	13.09	35.4	48.9					
	1798	−26.7	13.81	12.80	− 3.5	9.7					
	1799	−27.1	13.03	12.02	−44.7	−32.3					
	1800	5.4	14.00	12.99	31.8	45.2					
	1801	13.5	12.94	11.93	23.9	36.2					
1535 Mar. 1, '05 11h02m5											
1543 Mar. 8, '05 11h19m	1802	10.1	14.14	13.13	9.1	22.1					
	1803	11.2	15.05	14.04	7.0	20.9					
	1804	18.1	14.04	13.03	13.5	26.4					
	1805	15.6	14.44	13.43	15.0	28.3					
	1806	15.9	14.44	13.43	13.8	27.1					
	1807	15.0	14.34	13.33	16.8	30.0					
	1808	− 6.9	15.35	14.34	2.8	17.0					
	1809	− 9.4	13.23	12.22	− 1.4	10.7					
	1810	− 7.6	15.35	14.34	3.8	18.0					
	1811	−11.9	14.24	13.23	2.9	16.0					
	1812	−17.0	13.94	12.93	8.6	31.4					
	1813	14.1	14.24	13.23	− 1.9	11.2					
	1814	16.1	13.04	12.03	− 3.2	9.7					
	1815	24.3	14.34	13.33	− 4.7	8.5					
	1816	20.0	14.14	13.13	1.8	14.8					
	1817	22.1	14.14	13.13	0.6	13.6					
	1818	23.1	14.64	13.63	1.9	15.4					
	1819	18.8	14.44	13.43	9.1	22.4					
	1820	20.7	14.04	13.03	7.1	20.0					
	1821	20.4	14.14	13.13	12.8	25.8					
	1822	17.9	14.34	13.33	2.2	15.4					
	1823	22.3	14.14	13.13	−15.3	− 2.3					
	1824	24.9	14.74	13.73	−18.5	− 4.9					
	1825	32.0	13.43	12.42	−19.2	− 6.9					
	1826	27.1	14.14	13.13	−21.9	− 8.9					
	1827	38.4	13.73	12.72	− 3.6	9.0					
	1828	22.7	13.94	13.93	−11.9	0.9					
	1829	24.6	14.84	13.83	−13.9	− 0.2					
	1830	19.7	14.04	13.03	− 8.6	4.3					
	1831	10.2	14.34	13.33	−10.8	2.4					
	1832	9.9	14.54	13.53	0.3	13.7					
	1833	7.9	14.44	13.43	4.6	17.9					
	1834	8.3	14.74	13.73	11.7	25.3					
	1835	6.9	15.05	14.04	9.3	23.2					
	1836	4.6	14.44	13.43	7.9	21.2					
	1837	6.9	14.95	13.94	13.9	27.7					

TABLE I (*cont.*)

Epoch, Number, and Date	Number	Latitude	Daily Motion		Longitudes for Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1543 (*cont.*)	1838	4°4	15.25	14°24	14°8	28°9					
	1839	3 0	14.74	13.73	15.7	29.3					
	1840	6 6	14.84	13.83	17 8	31.5					
	1841	12.5	14.95	13.94	20 0	33.8					
	1842	6 0	15.15	14.14	18 2	32 2					
	1843	9.4	14.95	13.94	21.2	35 0					
	1844	−34.5	14.04	13.03	−19 2	− 6.3					
	1845	−37.5	13.13	12.12	−26 3	−14.3					
	1846	−34 2	14.34	13.33	−15 2	− 2.0					
	1847	−28 5	12 62	11.61	−15.3	− 3.8					
	1848	−32 0	14.34	13.33	−22 0	− 8.8					
	1849	9.1	14.34	13.33	−16 5	− 3.3					
	1850	8 6	15.55	14.54	−27 8	−13.4					
	1851	10.7	14.44	13.43	−32 5	−19.2					
	1852	9.3	13 43	12.42	−43 2	−30.9					
	1853	16 0	14.34	13.33	−19.9	− 6.7					
	1854	16 2	14.24	13 23	−22 3	− 9.2					
	1855	13.9	14.24	13.23	−28 6	−15.5					
1546 Mar. 9, '05											
1561 Mar. 30, '05	1469	−12 9	14.86	13.87	17.2	31.1	45°9				
	1470	− 8 0	15.94	14.95	17.0	32.0					
	1471	−12 3	14 09	13 10	15 9	29.2	43.0				
	1472	−14.8	14.71	13 72	15.7	29.5	44.1				
	1473	−17.7	14 28	13 29	17.4	30.7	44.9				
	1474	−21.5	13.32	12 33	11.9	24.0	37.4				
	1475	−19.8	13.89	12 90	7.5	20.8	34 2				
	1476	−15 0	14 95	13.96	5.2	19 4	34 1				
	1477	−14.5	14.86	13.87	3.3	17 0	32 0				
	1478	−11.4	14 67	13.68	− 4.1	9.0	24.2				
	1479	−17 5	14.91	13 92	− 2.9	11.2	25.9				
	1480	−18 0	14 33	13.34	− 5.7	7.6	21.9				
	1481	−23 2	13 65	12 66	− 2.9	9 9	23.3				
	1482	−20.5	14 57	13 58	−10.5	3.0	17.6				
	1483	−24 2	13.55	12.56	− 9.0	3.6					
	1484	−22 0	14.48	13 49	− 7.9	5.2	20.0				
	1485	−18 6	13 85	12 86	−13.7	− 0.8					
	1486	−11 9	13.75	12 76	− 9.9	2 9					
	1487	−12 3	14 43	13 44	− 8 0	5.4	19.8				
	1488	−26 4	14 67	13 68	− 9.6	4.0	18.7				
	1489	−24 2	14.62	13.63	−12 2	1.0	16.0				
	1490	−23 2	14 34	13 35	−14 2	1.1	13.4				
	1491	−20 3	14 84	13 85	−13.0	0 9					
	1492	−25 6	14 04	13 05	−15 0	− 2 0	12 0				
	1493	−24 1	13 85	12 86	−18 8	− 5.9					
	1494	−17 2	13 85	12 86	−19.3	− 6 6					
	1495	−11 0	13 85	12 86	−13.9	− 1.0					
	1496	−10 7	14 04	13 05	−18 2	− 5.1					
	1497	−27 2	13 75	12 76	− 3.2	9 6					
	1498	−27 5	13 89	12 90	−28 0	−15 0	− 1.3				
	1500	7 8	13 94	12 95	−37 9	−25 0	−11.1				
	1501	8 7	14 13	13 14	−41 7	−28.3	−14 5				
	1502	11 9	14 47	13 48	−43.1	−29 2	−15 2				
	1503	14 1	14 67	13 68	−42 8	−29 6	−14 5				
	1504	13 2	13 60	12 61	−38 7	−25 7	−12 6				
	1505	19 7	14 09	13 10	−35 0	−21 8	− 7 9				
	1506	22 5	14 04	13 05	−35 2	−22 3	− 8 2				
	1507	19 5	13 85	12 86	−38 7	−25 8					
	1508	17 5	14 76	13 77	−42 6	−28.1	−13 3				
	1509	17 0	14 47	13 48	−21 0	− 7.6	6 9				
	1510	19 7	14 94	13 95	−30 1	− 6 5					
	1511	15 5	15 04	14 05	−16 8	− 2 7					
	1512	21 1	13 74	12 75	−24 9	−11 1	1 5				
	1513	−14 7	14 43	13 44	− 4 3	9 1	23 3				
	1514	5 0	13 89	12 90	−41 3	−25 9	−11 9				

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1565	1474′	−20°6	13°56	12°57	27°7	41°1					
Mar. 31, '05	1516	−15.6	14.40	13.41	− 2.0	12.3					
9^h48^m	1517	−11.7	14.31	13.32	−17.9	− 3.7					
	1518	−21.3	13.56	12.57	−23.1	− 9.7					
	1519	12.8	13.65	12.66	15.0	28.5					
	1520	2.8	15.25	14.26	−37.5	−22.3					
	1521	7.5	14.31	13.32	−33.6	−19.4					
	1522	10.4	14.31	13.32	−33.3	−19.1					
	1523	14.1	14.22	13.23	−33.4	−19.3					
	1524	15.0	14.78	13.79	−34.8	−20.1					
	1525	16.8	14.78	13.79	−36.8	−22.1					
	1525′	−15.5	14.40	13.41	16.0	30.3					
	1526	13.3	13.65	12.66	−36.2	−22.7					
	1527	13.6	14.12	13.13	−39.0	−25.0					
	1528	18.9	13.56	12.57	−31.1	−17.7					
	1529	20.9	13.56	12.57	−29.3	−15.9					
	1530	21.5	14.22	13.23	−32.8	−18.7					
	1531	21.2	14.40	13.41	−37.8	−23.5					
	1532	26.7	13.47	12.48	−35.2	−21.9					
	1533	12.0	13.94	12.95	−42.1	−28.3					
1572											
Apr. 1, '05											
11^h23^m											
1588	1856	−17.4	14.33	13.35	7.1	6.0					
Apr. 17, '05	1857	−17.6	14.02	13.04	− 9.3	3.5					
9^h58^m	1858	−16.1	14.74	13.76	−11.2	2.3					
	1859	−14.1	14.43	13.45	−15.2	− 2.0					
	1860	−12.9	14.23	13.25	−16.2	− 3.2					
	1861	−11.2	14.02	13.04	−14.7	− 1.9					
	1862	−10.2	13.62	12.64	−10.2	2.2					
	1863	−13.6	14.84	13.86	25.4	39.0					
	1864	− 9.2	13.82	12.84	21.9	34.5					
	1865	−10.7	14.64	13.66	23.7	37.1					
	1866	−16.3	14.64	13.66	− 7.8	5.6					
	1867	23.3	14.23	13.25	19.1	32.1					
	1868	18.6	13.72	12.74	17.0	29.5					
	1869	23.9	13.41	12.43	23.2	35.4					
	1870	24.9	14.23	13.25	24.9	37.9					
	1871	23.0	13.62	12.64	26.7	39.1					
	1873	−24.6	14.23	13.25	21.1	34.1					
	1874	−28.3	14.43	13.45	26.3	39.5					
	1875	−21.9	14.53	13.55	4.9	18.2					
	1876	−19.1	14.74	13.76	2.2	15.7					
	1877	−23.4	13.62	12.64	2.1	14.5					
	1878	−23.6	13.92	12.94	16.8	29.5					
	1879	−25.5	13.72	12.74	15.3	27.8					
	1880	−17.6	13.92	12.94	13.0	25.7					
	1881	−18.6	15.04	14.06	21.3	35.1					
	1882	−19.8	14.23	13.25	25.9	38.9					
	1885	−18.7	14.02	13.04	−32.8	−20.0					
	1886	−16.8	14.74	13.76	−29.6	−16.1					
	1887	−17.1	14.94	13.96	−25.2	−11.5					
	1888	−18.9	13.92	12.94	−38.5	−25.8					
	1889	−21.9	14.23	13.25	−47.5	−34.5					
	1890	−27.4	14.33	13.35	8.8	21.9					
1590											
Apr. 18, '05											
9^h31^m											
1601	1891	−14.1	14.74	13.77	21.6	36.1					
Apr. 28, '05	1892	−15.4	14.36	13.39	18.9	33.0					
9^h37^m	1893	−20.6	14.08	13.11	14.1	27.9					
	1894	−20.3	13.79	12.82	11.8	25.3					

TABLE I—Continued

Plate Number and Date	Number	Latitude	Declination Measures		Differences from Catalogue Observations						
			Normal	Catalogue	1	2	3	4	5	6	7
1601 (*cont.*)	1895	−23°.9	15 38	14 01	2 2	15 9					
	1896	−26 3	15 81	12 32	4 5	17 9					
	1897	−27.5	14.46	13 49	6 8	20 8					
	1898	−28 5	14.17	13 20	9.0	22 9					
	1899	−27 3	13 42	12 [illegible]	− 9.6	3 3					
	1900	−10 9	14 93	13 96	− 3.0	11.7					
	1902	4.2	15 31	14 34	−17.2	− 2.1					
	1903	8 1	14.93	13 96	−22 0	− 7.3					
	1904	4 9	14.93	13 96	−10 2	4.5					
	1905	11.0	14.46	13.49	−11 1	3.1					
	1906	9 8	14 08	13.11	−15.7	− 1.9					
	1907	14 7	14 46	13 49	−10 2	4 0					
	1908	19 1	14 08	13.11	−19 8	− 6.0					
	1909	21 6	14.36	13.39	18 8	− 4.7					
	1910	20 8	13.60	12 63	−11.4	1.9					
	1911	19 4	14.17	13 20	−12 2	1.7					
	1912	10 8	14 65	13.68	−26.8	−12 4					
	1913	7 8	14 65	13.68	−29 1	−14.7					
	1914	19 9	14 65	13.68	−38 0	−23 6					
	1915	8 7	14 27	13 30	−32.7	−18 7					
	1916	11.5	13 51	12.54	−33 2	−20 0					
	1917	15 5	14.17	13 20	−32 2	−18 3					
	1918	17 7	15 41	14.44	30.1	45.3					
	1919	12 2	15 31	14.34	7.6	22 7					
	1920	10 1	13 89	12 92	2 1	16 0					
	1921	13 9	14 93	13 96	0.1	14 8					
	1922	18 7	14.27	13 30	− 2.1	11 9					
	1923	20 0	13 89	12 92	− 2 0	11.6					
	1924	21 8	14 27	13 30	1.3	15.3					
	1925	14 8	14 08	13 11	−38 6	−24 8					
	1926	16 0	13 98	13 01	−40 7	−27.0					
	1927	18 0	14.08	13.11	−40 9	−27.1					
	1928	21 3	13.41	12 44	−44.9	−31.8					
	1929	4 2	15 03	14 06	−34.0	−19 2					
1604 Apr. 29, '05 [illegible]											
1625 May 26, '05 [illegible]	1930	. 4	14 31	13 36	27 8	41 1					
	1931	−25 9	14 31	13.36	23 5	36 8					
	1932	−27 0	14 01	13 06	18 5	31 5					
	1933	−25 8	12 31	11 38	5 9	17 2					
	1934	−29 8	13 41	12 46	− 1.0	11 4					
	1935	−32 0	13 21	12 26	− 1.3	10 9					
	1936	−33 2	12 61	11 66	− 2.5	9 1					
	1937	−27 9	13 81	12 86	12 2	25 0					
	1938	3 4	13 04	13 67	6 6	20 2					
	1939	5 1	14 82	13 87	7 5	21 3					
	1940	− 8 7	14 01	13 06	−23 8	−10 8					
	1941	6 4	13 03	14 07	−48 7	−34 7					
	1942	19 9	14 11	13 16	−33 4	−20 3					
	1944	15 1	14 04	13 67	−23 2	− 9 6					
	1945	17 0	14 42	13 47	−22 4	− 9 0					
	1946	18 3	15 02	14 07	−21 0	− 7 0					
	1947	25 2	14 21	13 26	−19 3	− 6 1					
	1948	30 7	13 51	12 56	−20 5	− 8 0					
	1949	3 4	14 93	13 97	18 0	3 1					
	1950	18 2	14 34	13 38	18 0	3 1					
	[illegible]	15 1	14 11	13 16	−17 9	1 8					
	[illegible]	14 0	13 01	12 06	−20 7	− 7 8					
	[illegible]	8 7	15 12	14 17	−17 2	− 3 1					
	[illegible]	5 3	14 04	13 87	13 3	− 0 6					
	[illegible]	14 4	14 11	13 16	−10 1	3 0					
	[illegible]	11 1	14 62	13 67	− 9 6	4 0					
	[illegible]	10 8	15 03	14 07	4 0	3 1					
	[illegible]	13 3	14 01	13 06	− 7 0	6 0					
	[illegible]	12 0	14 62	13 67	1 0	12 6					

TABLE I *Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1625 *(cont.)*	1961	8°5	14°52	13.57	− 0°6	12°9					
	1962	16.8	13.31	12.36	− 0.6	11.7					
	1963	4.6	14.42	13 47	− 8.8	4.6					
	1964	8.3	14.72	13.77	−10.5	3.2					
	1965	17.9	14.52	13.57	− 6.2	7.3					
	1966	23.7	14.31	13.36	11.5	24.8					
1626 May 27, '05 10h03m											
1630 May 31, '05 10h36m	1967	18 8	13.89	12 94	−10 1	3.1	16°3	28°9			
	1968	17.5	13.85	12.90	− 9.4	3.5	16 9				
	1969	18.2	14.25	13.30	− 5.9	7.1					
	1970	3.6	14.56	13.61	2.0	15.3					
	1971	2 6	14.97	14.02	1.3	15.0					
	1972	23.3	14.77	13.82	33.0	46.5					
	1973	26.0	13.33	12.38	28.3	40.4					
	1974	20.1	14.25	13.30	32 0	45.0					
	1975	19.1	13.54	12.59	30 3	42.6					
	1976	3 2	14.05	13.10	3.3	9.5					
	1977	21.1	14.13	13.18	−23.9	−11.3	3.3	15.4			
	1978	24.4	13.81	12 86	−21.2	− 8.9	4.3	17.7		43°2	
	1979	26.8	13.95	13 00	−25.2	−12.5					
	1980	27.6	14.05	13.10	−27.1	14 3					
	1981	14.2	14.36	13.41	−11.5	1.6					
	1982	18.5	14.19	13.24	−14.0	− 0.2	13.3	25.9			
	1983	15.5	14.66	13.71	−16.1	− 2.7					
	1984	13.1	14.20	13.25	−12.2	0.7	14.8				
	1985	−11.9	14.34	13.39	−30.8	−17.2	3 5				
	1986	23.2	13.67	12.72	−26.1	−14.1	− 0.2				
	1987	21 3	14.46	13.51	−29.6	−16.4					
	1988	25.5	13.64	12.69	−29 4	−17.0					
	1989	27.0	14.97	14.02	−33.8	−20.1					
	1991	− 9.7	14.97	14.02	−35.1	−21.4					
	1992	−14.6	14.46	13.51	−15.8	− 2.6					
	1993	−20.3	14.15	13.20	5.1	18.0					
	1994	−27.0	14.04	13.09	8.0	22.1	34.7				
	1995	−23.0	14.66	13.71	9.6	23.0					
	1996	−20.2	13.85	12.90	10.7	23.3					
	1997	0.3	14.66	13.71	0 6	14.0					
	1998	4.0	15.28	14.33	16.0	30.0					
	1999	31.0	13.37	12.42	13.5	25.2	38.8				
1634 June 1, '05 10h03m	1990	−20.1	13.87	12.92	−30.1	−16.1	− 4.0				
	2000	28.0	13.49	12.54	28.3	41.6					
	2001	29.6	13.77	12.82	−24.8	−10.8	1.1				
	2002	33.3	13.96	13.01	−34.9	−21.1					
	2003	24.4	13.71	12.76	−15.0	− 1.6	10.8				
	2004	− 9.1	14.34	13.39	−21.4	− 7.2					
	2007	8.4	14.46	13.51	−44.7	−30.2	−17.2		10°2	22.9	
	2008	28.3	13.30	12.35	22.1	35.2					
	2009	19.4	13.87	12.92	−14.9	− 1.2					
	2010	19.3	13.71	12.76	−17.4	− 4.0	8.0		34.6	46.1	
	2011	23.1	13.84	12.89	−20.1	− 6.6	6.0		31.8	44.5	
	2012	29.7	13.01	12.06	−28.6	−16.2	− 4.8		19.7	31.8	
	2013	−17.7	14.61	13.66	−28.7	−14.2	− 1.0		26.7	39.6	
	2014	−22.3	14.01	13.06	−40.9	−27.2	−14.5				
	2015	10.4	15.10	14.15	−42.9	−27.9					
	2016	29.3	13.37	12.42	−37.5	−24.3	−12.1		12.8		
	2016′	32.0	13.19	12.24	−42.9	−30.0	−17.6		6.8	18.3	
1640 June 2, '05 11h30m	2017	22.4	13.85	12 90	6.7	19.1					
	2018	−11.7	14.68	13.73	− 3.0	10.2					
	2019	16.9	13.96	13.01	13.0	25.5					
	2020	20.0	13.99	13.04	0.4	12.5		39.3			
	2021	19.1	13.85	12.90	10.8	23.2					
	2022	9.1	14.89	13.94	−33.5	−20.1					

TABLE I—Continued

[illegible]	Number	Longitude	Diurnal Motion		Eccentricity and Date of Observation						
			Sidereal	Synodic	λ	φ	3	4	5	6	7
1640 [illegible]	2025	9°0	14 [illegible]	13°11	-35°3	-22°7					
	2024	8 1	14.16	13 21	-36 5	-23.8					
	2025	11.5	14.18	13 23	-40 2	-27.7		0°5	11°8		
	2026	-13 9	15 20	14 25	-16.9	- 3 2					
	2027	11 9	14.28	13.33	-29.1	-16 6		10.6	23.4		
	2028	-19 1	14 89	13.94	-19 5	- 6.1					
	2029	7 7	13.75	12 80	-37.4	-25 1					
	2027′	-17.2	15.31	14 36	-16 9	5 1					
1643	2030	-21 5	12 98	12 03	-10 3		13°3	25.8			
June 3, '05	2031	-18 4	13 98	13 03	-13.3		13.0	25.6			
[illegible]	2032	-23 3	13 62	12 67	-15 6		10 1				
	2033	9 4	14 24	13 29	-30 3		− 3.1	9.4		35°6	
	2034	11.5	14 68	13 73	-32 1		− 4.1	8 8			
	2035	26 4	13 17	12 22	- 0.1		24.7				
	2036	23 7	14 02	13 07	8 0		34.0	47 1			
	2037	26.3	14.01	13 06	9 2		35.5	48 2			
	2038	14 2	14 65	13.70	-18 6		9.2				
	2039	28 4	12 90	11 95	-10 0		14 8	25.5			
	2040	32 4	14.10	13.15	- 9 2		17.1	30 1			
	2041	11.8	14 26	13 31	-14 3		12.7				
	2042	15.1	14 44	13 49	-32.1		− 5.3	7.9		34.7	
	2043	17.7	14.32	13 37	-31 5		− 4.5	8.4			
	2044	17.5	13 77	12 82	-33.6		− 6.9	5.1		31 4	
	2045	16 0	13 86	12.91	-34.4		− 7.8	4 0			
1648	2046	29 6	13 96	13 01	27 1	39 5					
June 5, '05	2047	32 1	13.33	12 38	27 2	39 0					
[illegible]	2048	31.2	14 07	13.12	23 4	35.9					
	2049	35 5	13 96	13.01	17 1	29 5					
	2050	35 1	11.87	10 92	11 2	21.6					
	2051	37.5	14 07	13.12	12 4	24 9					
	2052	44 9	13.12	12 17	19 6	31.2					
	2053	43 3	13.75	12 80	20 7	32 9					
	2054	40 3	12 18	11.23	23 5	34.2					
	2055	10.7	14.45	13 50	5.0	17.8		44 5			
	2056	11 8	14 48	13 53	5.7	18.1		45 2			
	2057	6.3	14 65	13 70	3 1	16 2		43 2			
	2058	13.7	14 28	13 33	- 6.5	6 2					
	2060	22.4	13 96	13 01	-23.3	-11 2		14.7			
	2061	21 5	14 59	13 64	-18 2	- 5.2					
	2062	27.0	14.39	13 44	- 6 6	6 0		32 7			
	2063	22 7	14 59	13 64	-35 0	-22 0					
	2064	12 3	14 14	13 19	-29 7	-17.1		8 9			
	2065	-22 4	14 38	14 43	23 1	35 9					
	2068	-17 3	14 91	13 96	- 1.5	11.8					
	2069	- 7.7	14.35	13.40	-41.0	-28.3		− 1.8			
	2070	16 2	14.80	13 85	- 1.0	12.2					
1659	2071	8 9	14 93	13 98	20 1		47.7				
[illegible]	2074	- 4.4	14 53	13 58	-46 9		−20 1				
[illegible]	2075	- 7 8	15 34	14 39	-43 2		−14 8				
	2076	- 9 1	14 63	13 68	-44 0		−17 0				
	2077	14 2	14 28	13 33	11 3		37 6				
1662											
June 8, '05											
[illegible]											
1666	2078	−11 8	15 03	14 08	21 2	[illegible]					
June 15, '05	2079	−13 3	14 [illegible]	13 [illegible]	17 5	[illegible]	34 6				
[illegible]	2080	−11 3	18 01	17 06	15 3	[illegible]					
	2081	− 9 8	13 75	12 80	12 5	[illegible]					
	2082	− 8 7	13 88	12 93	11 1	[illegible]					
	2083	-19 [illegible]	14 37	13 42	17 4	[illegible]	33 9				
	2084	-19 [illegible]	13 92	13 07	17 1	[illegible]	33 7				
	2085	15 1	14.05	13 70	19 3	40 0					
	2086	17 2	14 80	13 85	19 3	40 0					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1666 (*cont.*)	2087	−23°5	13°73	12°78	10°1	20°2	35°5				
	2088	−18.9	14.33	13.38	7.2	17.3	33.8	44°2			
	2089	17.2	14.90	13.95	26.3	37.2					
	2090	−23 3	13.89	12.94	4.8	14.8	30.5				
	2091	−21.1	14.14	13.19	3.5	13.9	30.1	40 0			
	2092	−14.9	14.01	13.06	3.3	13.5					
	2093	−15.6	14.38	13.43	1.4	11.5	27.5	38.8			
	2094	−17.7	14.23	13.28	1.5	12.0	27.9				
	2095	−13.9	14.77	13.82	0.4	11.2					
	2096	−20.1	14.39	13.44	0.4	10.9					
	2097	−23.2	14.44	13.49	0.1	10.4	26.8	37.5			
	2098	−18.0	13.24	12.29	− 0.8	8.8					
	2099	−19.8	13.24	12.29	− 1.3	8.3					
	2100	−22.2	13.86	12.91	− 3.0	7.3	22.8	32.9			
	2101	−16.6	14.39	13.44	− 3.0	7.5					
	2102	−13.7	14.70	13.75	− 5.0	5.0	22.0	32.5			
	2103	−15.4	14.18	13.23	− 6.8	3.0	19.3	29.8			
	2104	−18.9	13.75	12.80	− 7.0	3.0					
	2105	−17.3	14.29	13.34	− 8.1	1.1	17.8	28.7			
	2106	−17.9	13.24	12.29	−10.4	− 0.8					
	2107	−19.8	14.13	13.18	−10.0	0.3					
	2108	−11.9	13.24	12.29	− 9.7	− 0.1					
	2109	−14.3	14.19	13.24	−12.0	− 1.7	14.3				
	2110	−19.7	14.60	13.65	−14.2	− 4.5	12.8				
	2111	−17.9	14.76	13.81	−14.2	− 4.5	13.0	23.8			
	2112	−15.8	14.47	13.52	−14.7	− 4.3	12.1	22.8			
	2113	−16.2	13.75	12.80	−16.3	− 6.3					
	2114	−16.3	14.17	13.22	−20.2	−10.8	5.9	16.2			
	2115	−19.0	14.42	13.47	−19.8	− 9.7	6.8	17.5			
	2116	5.3	14.35	13.40	−15.0	− 5.1	11.1	22.2			
	2117	7.6	14.79	13.84	−16.2	− 5.8	11.2	22.1			
	2118	10.9	13.90	12.95	−19.6	− 9.7	6.1				
	2119	8.5	14.29	13.34	−23.9	−13.5	2.6				
	2120	5.5	14.76	13.81	−25.7	−16.0	1.0	12.5			
	2121	3.0	14.61	13.66	−26.8	−17.2	0.4				
	2123	23.7	13.88	12.93	− 5.9	4.2					
	2124	25.2	14.45	13.50	0.0	9.7	26.7				
	2125	21.9	13.62	12.67	− 4.5	5.4					
	2126	20.5	14.65	13.70	− 6.0	4.7					
	2127	19.3	13.65	12.70	− 4.0	5.1	20.8	31.1			
	2128	20.7	13.37	12.42	− 0.2	9.5					
	2129	18.5	13.82	12.87	− 2.3	7.6	23.2	33.4			
	2130	15.5	14.23	13.28	1.9	11.3	28.0	38.5			
	2131	23.7	14.13	13.18	14.9	25.2					
	2132	21.0	14.02	13.07	12.7	23.2	38.7				
	2133	21.2	15.29	14.34	18.5	29.7					
	2134	18.1	15.06	14.11	14.6	24.6	42.5				
	2135	17.0	14.52	13.57	17.6	28.2					
	2136	14.8	14.01	13.06	17.8	28.0					
	2137	−17.8	15.02	14.07	−12.0	− 2.1	15.8				
	2138	−19.2	13.24	12.29	−13.0	− 3.4					
	2139	−20.7	13.49	12.54	− 6.8	3.0					
	2140	−18.2	14.87	13.92	− 6.5	4.3					
	2141	16.8	13.74	12.79	− 6.6	3.3	18.8				
1668	2142	−16.8	14.76	13.81	15.3	31.7	42 9				
June 14, '05	2143	−14.6	14.57	13.62	− 8.2	8.9	18.9				
10^h09^m	2144	−19.3	15.13	14.18	− 6.6	10.5	21.7				
	2145	−21.1	15.08	14.13	− 6.9	10.9	21.2				
	2146	1.9	14.47	13.52	1.6	17.9					
	2147	−15.8	14.47	13.52	22.5	38.8					
	2148	21.1	14.06	13.11	7.2	23.0					
	2149	−19.4	14.47	13.52	3.5	19.8	30.9				
1677	2150	−24.9	14.73	13.78	37.4	48.3					
June 15, '05	2151	12.3	14.73	13.78	32.9	43.8					
3^h05^m	2152	−10.2	14.73	13.78	12.3	23.2					
	2153	−21.7	14.48	13.53	27.0	37.7					
	2154	20.2	13.47	12.52	30.5	40.4					
	2155	23.9	14.86	13.91	20.2	31.2					

TABLE I—*Continued*

Planet Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
1677 [illegible]	2156	11°3	13°72	12°77	−29°2	−19°1					
	2158	10 4	13.59	12 64	−34.7	−24.7					
	2159	11.4	13.72	12 77	−31.0	−20.9					
	2160	13.7	13.97	13 02	−36 3	−26.0					
	2161	3 8	15 36	14.41	− 6.9	4.5					
	2162	21.6	13 35	13 40	25.7	36 3					
1682 [illegible]											
1686 June 21, '05 11°00	2163	14.8	14.99	14.04	15 0	28.8					
	2164	15.4	14 59	13.64	12.3	25.7					
	2165	12 6	15 20	14 25	14.0	28.0					
	2166	12.7	14.79	13.84	17.9	31.5					
	2167	18.6	14.89	13 94	27.3	41.0					
	2168	1 8	15 20	14 25	31.9	45.9					
	2169	2.7	15.60	14 65	19 0	33.4					
	2170	15.0	14.89	13 94	4.7	18.4					
	2171	14 9	13.91	12 96	− 4.7	8.4		34°0			
	2172	12.2	14.06	13 11	0 3	13.2		39.5			
	2173	18 7	14.01	13 06	− 4.5	8.2		34.5			
	2174	19 7	15 20	14 25	7.4	21.4					
	2175	30 0	13.47	12.52	21.7	34.0					
	2176	−24.1	13 26	12.31	12.9	25.0					
	2177	−21 2	14.18	13.23	15.0	28.0					
	2178	−19.3	13.87	12.92	18 3	31.0					
	2179	−20 8	15.10	14.15	19 9	33.8					
	2180	−23.7	14.59	13.64	19.6	33.0					
	2181	−27.3	13.47	12.52	18.0	30.3					
	2182	−29.8	14.18	13.23	22 2	35.2					
	2183	−24.7	14.08	13.13	6.8	19.7					
	2184	−30 9	13.67	12.72	7.5	20.0					
	2185	−27.1	13.37	12.42	7.0	19.2					
	2186	−27.3	14.08	13.13	13.5	26 4					
	2187	−14.2	13.87	12 92	15.0	27.7					
	2188	20 0	14.00	13.05	−23.1	−10.3		15.9			
	2189	17.2	13.57	12 62	−20.3	− 7.9					
	2190	11.3	15 30	14 35	−17.8	− 3.7					
	2191	10 6	14 99	14.04	−15 9	− 2.1					
	2192	11.5	14.09	13 14	−12 1	0 9		27 2			
	2193	8 2	14 38	13 43	−15.7	− 2.5					
	2195	6 5	14 28	13 33	− 9.5	3 6					
	2196	5 2	14 28	13 33	−19 5	− 6.4					
	2197	5 9	14 89	13 94	−24 5	−10 8					
	2199	21 3	13 78	12 83	−27 2	−13 9		11 3			
	2200	20 8	13 96	13 01	−31.1	−18.2		7.8			
	2201	16 7	14 07	13.12	−33 3	−20.5		5.9			
	2202	16 8	13 66	12 71	−35 3	−22 8		2 7			
	2204	16 8	13 67	12 72	−39 5	−26 1		− 1.3			
	2204	19 6	14 09	13 14	−44 1	−31.0		1 8			
1689 June 22, '05 [illegible]	2206	22 3	13 11	12 16	9 8		34 2				
	2207	16 5	13 86	12 91	5.7		31 6				
	2208	8 4	13 41	12 46	5 8		30 8				
	2209	5 1	14 61	13 66	6 1		33 5				
	2210	21 6	14 06	13 11	− 3.2		23 1				
	2211	20 7	13 41	12 36	− 5 1		19 7				
	2212	18 2	14 41	13 36	0 9		27 7				
1692 [illegible]											
[illegible]	2214	− 1 9	14 36	13 39	21 4		35 9				
Apr. 26, '07 [illegible]	2213	− 4 9	14 92	13 95	17 8		32 9				
	2215	14 6	15 47	14 50	17 4		37 8				

TABLE 1—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Disk—Observers						
			Sidereal	Synodic	1	2	3	4	5	6	7
2202 (*cont.*)	2216	17°.4	14°.64	13.67	22°.0	36°.8					
	2217	12 .9	13.90	12.93	29 .0	43.0					
	2218	17 .1	15.38	14.41	32.9	48.5					
	2219	17 .0	15.01	14.04	30.7	45 .9					
	2220	16 .9	15.10	14.13	28.2	43.5					
	2221	12.7	15.10	14.13	33.5	48.8					
	2222	15 .5	15.29	14.32	8.7	24.2					
	2223	19.8	14.64	13.67	5.0	19.8					
	2224	23.8	14.27	13.30	0.9	15.3					
	2225	17.1	15 01	14.04	2.8	18.0					
	2226	10 .6	14.92	13.95	7.4	22.5					
	2227	7 .9	15.19	14.22	14.0	29.4					
	2228	9.1	15.01	14.04	15.1	30.3					
	2229	4.7	14.55	13.58	13.7	28.4					
	2230	7.5	14.73	13.76	7.2	22.1					
	2231	0.1	14.92	13.95	0.4	15.5					
	2232	− 0.3	15.10	14.13	− 1.7	13.6					
	2233	20.3	13.72	12.75	− 3.8	10.0					
	2234	34.9	13.99	13.02	−12.0	2.1					
	2235	38.6	14.09	13.12	−16.0	− 1.8					
	2237	− 8.1	14.46	13.49	−14.2	0.4					
	2238	− 8.7	14.92	13.95	−19.2	− 4.1					
	2239	− 6.2	14.92	13.95	−17.7	− 2.6					
	2240	−12.6	14.73	13.76	33.5	48.4					
	2241	−16.4	13.53	12.56	20.0	33.6					
	2242	−17.2	14.55	13.58	18.0	32.7					
	2243	−16.4	14.64	13.67	−22.2	− 7.4					
	2244	−16.3	14.27	13.30	−26 .0	−11.6					
	2245	−13.9	13.72	12.75	−28.8	−15.0					
	2246	−15.9	12.89	11.92	−39.5	−26.6					
	2247	−18.8	13.90	12.93	−43.5	−29.5					
	2248	5.8	14.46	13.49	−14.0	0.6					
2208 Apr. 27, '07 11^h44^m											
2209 May 1, '07 8^h52^m	2249	16.6	14.89	13.92	0.2	14.9		42°.7			
	2250	18.6	13.98	13.01	− 1.7	11.5		37.9			
	2251	16.7	14.03	13.06	− 2.2	10.7		37.5			
	2252	12.2	13.35	12.38	− 0.1	12.4					
	2253	11.1	13.35	12.38	− 0.3	12.2					
	2255	11.1	14.28	13.31	− 5.2	8.2		35.3			
	2256	13.5	14.59	13.62	− 6.0	7.0		35.3			
	2257	16.5	13.94	12.97	− 8.5	4.8					
	2258	14.0	14.01	13.07	− 8.9	4.3					
	2259	11.2	13.55	12.58	1.5	14.2					
	2260	8.0	14.30	13.33	− 7.0	6.1		33.5			
	2261	19.2	14.54	13.57	−11.7	2.0					
	2262	21.5	13.85	12.88	− 5.2			34.0			
	2263	24.5	14.26	13.29	− 8.7	4.9		31.8			
	2264	−19.5	14.93	13.96	15.7	29.8					
	2265	−20.8	15 03	14.06	20.4	34.6					
	2266	−16.9	14.34	13.37	22.7	36.2					
	2267	−20.6	14.84	13.87	22.8	36.8					
	2271	−17.2	14.25	13.28	−11.6	1.7		28.8			
	2272	−17.0	13.74	12.77	−13.2	− 0.1		25.7			
	2273	−22.2	13.94	12.97	− 9.0	2.7		30.2			
	2274	−22.3	14.18	13.21	−13.8	− 1.0		26.3			
	2275	−20.2	13.94	12.97	− 4.2	8.0		35.1			
	2276	−16.1	14.14	13.17	− 9.8	3.5					
	2277	−17.1	13.65	12.68	− 8.0	4.8					
	2278	−12.2	13.45	12.48	−11.8	0.8					
	2279	− 4.8	15.03	14.06	−17.9	− 3.7					
	2280	−15.0	13.75	12.78	−21.0	− 7.6		18 0			
	2281	−16.4	14.71	13.74	−23.1	− 9.4		18.7			
	2282	−14.7	14.50	13.53	−24.1	− 9.9		17.2			
	2283	−16.9	14.36	13.39	−27.8	−14.1		13.0			
	2284	−18.5	14.70	13.73	−32.5	−18.7		9.3			

TABLE I—Continued

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
[illegible]	[illegible]	- 7°0	14°25	13°28	-24.7	-10.9		15°8			
	[illegible]	-10 3	14 54	13 57	-29.7	-16.0					
	[illegible]	-19 4	14 19	13 22	-36 2	-22.5		4 1			
	[illegible]	-10 5	14 93	13 96	-24 1	-10.0					
	[illegible]	[illegible]	14 20	13 23	-28 9	-15.2		11.8		37.7	
	[illegible]	18 1	[illegible]	12 96	-29 6	-16.2		9.7		35.8	
	2291	14 3	14.26	13 29	-35 6	-22.0		5.2		31.3	
	2292	16 9	13 99	13 02	-24.4	-11.4		15 2			
	[illegible]	13 0	14 18	13 21	-24 6	-12.0		14.8		41.8	
	2294	10.1	14 04	13.07	-25.4	-12.2					
	[illegible]	11.9	14 24	13 27	-27.5	-14.1					
	[illegible]	8 5	14 64	13.67	-31.1	-17.3					
	[illegible]	8 5	[illegible]	13.47	-32 6	-19.0					
	[illegible]	7.6	14 04	13 07	-34.3	-20.6		5.5		31.3	45°1
	2299	29 4	[illegible]	12 76	-42 2	-30.0		-3.5			
	[illegible]	18 8	14.10	13.13	-37.0	-24.0		2.9			
	[illegible]	31.2	13.84	12 87	-39.0	-26.0					
[illegible]	2302	10 8	14 15	13 18	-18 8		8°0				
May 2, '07 [illegible]	2254	11.4	[illegible]	13 57	10.2		37.8				
2224	2302'	16.2	[illegible]	[illegible]	5.2		32.2	45.0			
May 4, '07 [illegible]	2303	-21.1	[illegible]	13.48	-22.4		4.6	17.9			
	2304	-25 7	15.28	14.32	-11.3		17.2				
	2305	[illegible]	13 93	12 97	-26.1		0.0	12.6	25°6		
	2306	-29 5	13 88	12.92	-25.0		0.7				
	2307	-29 7	13 98	13 02	-31.4		- 5.5				
	2308	-29 3	14 01	13 05	-34.8		- 8.5	4.9	16.9		
	2309	-37.6	13.63	12 67	-38.0		-12.5	0.0	11.8	25.4	
	2310	-25 6	13.93	12.97	-30.2		- 4.4				
	2311	-21 0	14 53	13.57	-44.8		-17.8				
	2312	-18 4	14 53	13 57	-42.6		-15.6				
	2313	-17.8	14.50	13.54	-35.4		- 8.7	5.2			
	2314	-15.4	14 49	13.53	-31.8		- 5.3	8.8			
	2315	-15 0	14.41	13.45	-46.5		-20.2	7.3	6.7	20.4	
	2316	-11.6	14.40	13.44	-41.0		-14.1	- 0.8			
	2317	-20.9	13 90	12.94	-15.9		9.4	22.8	35.7		
2226	2319	9 0	13 21	12.25	28 7	42.0					
May 6, '07 [illegible]	[illegible]	[illegible]	[illegible]	13.33	3 7	17.5	30.2				
	[illegible]	-17 9	[illegible]	13.50	-19 3	- 6.9	7.1	20.7			
	2322	-17 1	13.62	12 66	-27 2	-14.5					
	[illegible]	-17 2	13 32	12 36	-29 2	-16.8					
	2324	-10 9	14 69	13 73	-35 5	-21.5	- 8.2				
	2325	- 6 3	14 47	13.51	-38 8	-25.4	-13.1	1.8			
	2326	-12 5	14.61	13.65	- 8.7	5.0					
	2327	-37.2	13 63	12.67	-24.3	-11.7	0.9				
	2328	17 2	14 31	13 35	22.2	35.6					
	2329	-11 1	14 31	13.35	30.0	43.4					
	2330	-20 5	13 72	12.76	30.3	43.1					
	2331	14 4	15 21	14.25	19.7	34.0					
	2332	15 0	13.72	12 76	23 3	36.1					
	[illegible]	14 4	14 31	13·35	28 9	42.3					
[illegible]	[illegible]	-13 4	14 87	13 91	-35.5	-21.8					
May 7, '07 [illegible]	[illegible]	-16 2	14.58	13 62	-36.1	-22.8	- 9.2				
	2337	-13 7	14 88	13 92	-37.7	-24.1	-10.2				
	[illegible]	- 9 6	14 78	13 82	-28.6	-14 5	- 1.3				
	[illegible]	-12 5	14 26	13 30	-39.2	-26.1					
	[illegible]	-13 5	14 26	13 30	-40 4	-27 3					
	[illegible]	-18 1	14 36	13 40	-34.1	-20.9					
	[illegible]	-34 2	13 76	12 80	[illegible]	[illegible]					
	[illegible]	-27 1	13 92	12 96	[illegible]	21 8	34 3				
	[illegible]	[illegible]	15 58	14 62	2 0	16.4					
	[illegible]	-11 9	14 37	13 41	-23 8	-10 8	2 7				
	[illegible]	-16 8	14 97	14 01	-26 5	-12.7					
	2347	-18 2	14 77	13 81	0 4	14 0					
	[illegible]	-19 2	[illegible]	14.17	- 8 2	6 3	19 8				

TABLE I—*Continued*

PLATE NUMBER AND DATE	NUMBER	LATITUDE	DIURNAL MOTION		LONGITUDE FROM DIFFERENT CENTRAL MERIDIANS						
			Sidereal	Synodic	1	2	3	4	5	6	7
2238 (*cont.*)	2347′	−16°.5	14°.67	13.71	−33°.7	−20°.2					
	2342′	−17.6	13.97	13.01	−12.7	0.2	13.0				
2242	2350	−38.2	13.47	12.51	5.5	17.9					
May 8, '07	2351	−15.4	14.28	13.32	9.9	23.1					
9^h23^m	2352	− 6.6	14.58	13.62	19.2	32.7					
	2353	−19.4	14.28	13.32	9.6	22.8					
	2354	−31.0	13.47	12.51	4.0	16.2					
	2355	−33.4	14.58	13.62	11.3	24.8					
	2356	−35.6	13.78	12.82	5.2	17.9					
	2357	−15.6	14.55	13.59	−29.4	−16.0		12°.0		39.3	
	2358	7.7	14.68	13.72	−16.8	− 3.2					
2250											
May 9, '07	2361	−17.4	14.52	13.56	− 7.0		20.6		18.0		
9^h10^m											
2258	2362	−16.7	14.30	13.34	−36.9		−10.9				
May 11,' 07	2363	−18.4	13.69	12.73	−25.2		− 0.4				
11^h40^m	2365	15.9	14.15	13.19	−26.0		− 0.3				
	2366	14.0	13.74	12.78	−23.6		1.3				
2260											
May 13, '07											
10^h26^m											
2265	2367	−16.8	15.50	14.54	25.3	39.1					
May 17, '07	2368	−16.1	14.34	13.38	20.5	33.2					
10^h56^m	2369	−20.8	15.08	14.12	29.0	42.4					
	2370	−20.0	14.76	13.80	33.0	46.1					
	2371	−17.6	14.65	13.69	36.3	49.3					
	2372	−17.2	14.65	13.69	33.8	46.8					
	2373	−15.5	14.55	13.59	31.0	43.9					
	2374	−23.1	13.60	12.64	16.9	28.9					
	2375	−12.9	14.55	13.59	2.4	15.3					
	2376	−13.1	14.55	13.59	− 8.9	4.0					
	2377	−25.2	14.76	13.80	− 3.5	9.6					
	2378	13.6	14.44	13.48	0.3	13.1					
	2379	4.0	15.39	14.43	9.3	23.0					
	2380	9.7	16.02	15.06	5.0	19.3					
	2381	6.9	15.39	14.43	3.8	17.5					
	2382	5.7	15.39	14.43	− 3.7	10.0					
	2383	10.9	14.97	14.01	− 6.6	6.7					
	2384	18.5	13.52	12.56	− 8.3	4.2		29.0			
	2385	20.0	14.02	13.06	11.9	24.3					
	2386	8.2	14.26	13.30	−26.8	−13.9		12.5	25.9		
	2387	6.9	14.15	13.19	−23.9	−11.1		15.0	28.4		
	2388	4.7	14.26	13.30	−30.2	−17.2		9.4	22.4		
	2389	8.1	14.38	13.42	−32.7	−19.2		6.8	20.8		
	2390	11.2	14.55	13.59	−32.9	−20.0					
	2391	10.7	14.65	13.69	−35.0	−22.0					
	2392	18.9	13.92	12.96	−27.6	−15.5		10.7			
	2393	20.8	13.58	12.62	−30.8	−18.5		6.6			
	2394	23.2	12.97	12.01	−32.6	−21.2					
	2395	−23.8	14.44	13.48	−24.0	−11.2					
	2396	−23.1	14.13	13.17	−26.9	−14.4					
	2397	12.4	13.92	12.96	−44.0	−31.7					
	2398	11.3	14.13	13.17	−42.8	−30.3					
	2399	9.1	15.60	14.64	12.9	26.8					
2270	2400	6.0	13.95	12.99	−20.2		5.9				
May 18, '07	2401	−18.3	14.91	13.95	−42.9		−15.0	− 1.0			
9^h43^m	2402	7.6	14.24	13.28	−16.1		10.3	23.8			
2275	2403	12.2	14.09	13.13	2.3	15.3					
May 20, '07	2404	14.8	14.59	13.63	1.2	14.7					
9^h57^m	2405	8.8	14.29	13.33	− 6.2	7.0					
	2406	8.8	14.09	13.13	−18.7	− 5.7					
	2407	−24.6	14.19	13.23	−23.8	−10.7					
	2408	−14.6	14.09	13.13	−21.8	− 8.8					
	2409	−15.5	14.59	13.63	−26.0	−12.5					
	2411	−13.6	14.29	13.33	−27.2	−14.0					

TABLE I *Continued*

Plate No. Name Date	No.	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
2275 (*cont.*)	2412	−12°9	13°58	12°62	−23°2	−10°7					
	2413	−17.6	13.68	12.72	−19.9	− 7.3					
	2414	7.8	13.58	12.62	−22.6	−10.1					
	2415	9.9	14.19	13.23	−30.4	−17.3					
	2416	17.5	14.19	13.23	−28.3	−15.2					
	2417	8.7	14.39	13.43	−27.6	−14.3					
	2418	5.7	14.09	13.13	−28.6	−15.6					
	2419	4.9	13.99	13.03	−20.2	− 7.3					
	2420	4.6	14.49	13.53	−23.3	− 9.9					
	2421	1.8	14.90	13.94	−28.2	−14.4					
	2422	−12.0	13.78	12.82	−43.4	−30.7					
	2423	14.0	14.09	13.13	− 5.7	7.3					
	2426	−22.9	14.49	13.53	− 4.6	8.8					
2278 May 21, '07											
2282 June 5, '07	2427	−13.0	14.96	14.01	34.9	49.0					
	2429	−17.9	14.36	13.41	23.4	36.9					
	2430	−18.8	14.06	13.11	21.2	34.4					
	2431	−19.7	14.96	14.01	14.4	28.5					
	2432	−14.3	14.26	13.31	20.9	34.3					
	2433	−21.1	14.26	13.31	9.8	23.2					
	2434	−20.8	13.86	12.91	21.3	34.3					
	2435	−33.2	14.16	13.21	14.6	27.9					
	2436	−28.6	13.86	12.91	9.8	22.8					
	2437	−36.1	14.56	13.61	8.3	22.0					
	2438	−34.4	13.27	12.32	6.7	19.1					
	2439	−35.3	13.27	12.32	4.0	16.4					
	2440	−39.6	13.67	12.72	− 7.7	5.1					
	2441	−40.8	13.59	12.64	− 5.2	7.9		32°6			
	2442	− 9.8	14.29	13.34	12.1	25.9		52.0			
	2443	− 6.5	14.75	13.80	9.3	23.3		50.5			
	2444	− 0.9	14.96	14.01	10.0	24.1					
	2445	4.7	14.99	14.04	8.4	22.0		50.2			
	2446	4.8	14.36	13.41	6.2	19.7					
	2447	9.1	13.86	12.91	7.1	19.9		45.6			
	2448	8.6	14.30	13.35	3.0	16.7		42.9			
	2449	5.6	15.06	14.11	6.7	20.3		48.7			
	2450	− 2.2	14.06	13.11	4.8	18.0					
	2451	0.8	14.58	13.63	4.2	18.0		44.9			
	2452	3.2	14.36	13.41	− 2.5	11.0					
	2453	4.1	15.26	14.31	− 5.7	8.7					
	2454	8.3	14.67	13.72	− 5.7	7.9		35.2			
	2455	− 2.0	14.16	13.21	− 3.5	9.8					
	2456	−10.5	14.54	13.59	1.6	15.5		42.2			
	2457	−14.6	14.43	13.48	2.8	16.2		43.0			
	2458	−16.1	14.76	13.81	− 1.9	12.0					
	2459	−14.7	14.03	13.08	− 5.2	7.7		33.8			
	2460	−18.9	13.96	13.01	−12.0	1.1					
	2461	−22.4	13.86	12.91	−19.0	− 6.0					
	2462	13.0	13.96	13.01	−21.0	− 7.9					
	2463	14.7	13.27	12.32	−23.9	−11.5					
	2464	13.1	14.49	13.54	−26.1	−13.0		14.2			
	2465	14.2	13.71	12.76	−27.7	−15.1		10.8			
	2466	18.1	13.17	12.22	−36.8	−24.5					
	2468	9.7	14.32	13.37	−11.4	2.1		28.5			
	2469	−11.0	13.85	13.00	−15.9	− 2.8		22.9			
	2470	−16.1	13.07	12.12	−18.9	− 6.7					
2285 June 19, '07	2471	−18.4	14.85	13.90	16.1		4.6				
	2472	0.0	13.99	13.14	− 2.0		24.0				
	2474	1.0	13.99	14.05	10.7		38.5				
	2475	9.3	14.75	13.80	12.2		40.5				
	2476	7.0	14.40	13.80	5.2		32.5				
	2477	18.4	13.23	13.29	17.0		39.3				

TABLE I—*Continued*

PLATE NUMBER AND DATE	NUMBER	LATITUDE	DIURNAL MOTION		LONGITUDES OR DIFFERENCES						
			Sidereal	Synodic	1	2	3	4	5	6	
2301 June 8, '07 9^h52^m											
2309 June 13, '07 10^h37^m5	2478	7°9	15°58	14°63	10°1	21°2					
	2479	7.9	14.75	13.80	−22.5	− 9.2					
	2480	9.5	15.54	14.59	−26.0	−12.8	2.6				
	2481	7.1	14.51	13.56	−27.8	−14.8	− 1.2				
	2482	12.7	14.75	13.80	−28.3	−15.0					
	2484	9.0	15.06	14.11	−35.6	−22.0					
	2485	9.3	14.23	13.28	−30.1	−17.3					
	2486	−15.5	14.87	13.92	−18.0	− 4.7	9.3				
	2487	−24.1	14.46	13.51	−18.0	− 5.1	8.5				
	2488	−22.4	14.44	13.49	−12.0	1.0					
	2489	−18.1	14.51	13.56	− 8.5	4.3	18.1				
	2490	−20.5	14.75	13.80	− 5.2	8.1					
	2491	−18.9	15.06	14.11	− 2.3	11.3					
	2492	−13.4	14.65	13.70	− 2.4	10.8					
	2493	−10.9	15.17	14.22	− 3.9	9.8					
	2494	−15.3	14.96	14.01	− 4.7	8.8					
	2495	−12.5	14.51	13.56	− 6.1	7.2	20.5				
	2496	− 9.9	14.37	13.42	− 7.9	5.7	18.8		45.2		
	2497	−15.0	14.77	13.82	−11.3	2.2	15.8				
	2498	−16.8	14.15	13.20	−13.0	− 0.2	12.9				
	2499	−26.7	14.07	13.12	−33.2	−20.6	− 7.7		18.1	32°3	
	2500	−19.9	14.41	13.46	−32.1	−19.2	− 5.7				
	2501	−16.5	14.51	13.56	−27.9	−15.1	− 1.3				
	2502	−17.8	14.13	13.18	−24.5	−11.8					
	2503	−17.1	14.46	13.51	−20.4	− 7.6	6.1				
	2478′	6.1	14.96	14.01	12.0	25.5					
2314 June 14, '07 9^h45^m	2483	12.9	14.58	13.63	−19.5	− 5.9					
	2487′	−27.3	13.38	12.43	−11.2	1.2					
	2504	7.2	15.38	14.43	0.0	14.4					
	2505	− 7.0	13.88	12.93	35.5	48.4					
	2506	−12.8	13.88	12.93	12.8	25.7					
	2507	8.1	14.98	14.03	−4.0	10.0					
	2508	5.5	14.16	13.21	−15.0	− 2.1		24°3			
	2509	11.8	14.59	13.64	−24.9	−10.9		15.6	30.1		
	2510	11.1	14.40	13.45	−47.0	−35.5		7.5	6.1	20.6	32°8
	2511	−24.2	14.28	13.33	−11.8	0.9		27.7	41.5		
	2512	−18.5	14.11	13.16	−16.2	− 3.0		23.0			
2318 June 15, '07 9^h42^m	2513	13.1	14.63	13.68	− 8.5		18.3	32.8			
	2514	−21.5	13.93	12.98	− 7.4		18.3				
	2515	−19.0	14.28	13.33	13.0		39.4				
2324 June 17, '07 9^h14^m	2516	10.0	14.98	14.03	− 1.5	13.0					
	2517	−24.2	14.69	13.74	3.2	17.4					
	2519	9.8	14.24	13.29	− 8.7	4.7	19.2	31.2			
	2520	−16.8	14.40	13.45	−20.5	− 6.6					
	2521	−21.2	13.92	12.97	−28.5	−15.1					
	2522	−17.8	14.60	13.65	−30.8	−16.7					
	2523	−17.1	14.53	13.58	−33.2	−19.1	− 4.9	7.4		34.8	
	2524	−11.9	14.04	13.09	−31.2	−18.0	− 3.7	8.0		34.2	
	2525	−15.3	14.13	13.18	−36.7	−23.0	− 9.0	3.0			
	2526	−13.5	13.92	12.97	−38.1	−24.7					
	2527	− 9.2	13.82	12.87	−33.3	−20.0					
	2528	− 6.0	14.62	13.67	−32.7	−19.0	− 4.5	8.5			
	2529	− 7.1	14.27	13.32	−34.8	−20.8	− 6.7				
	2530	−15.7	14.19	13.24	−24.9	−10.9	2.7	15.2		41.4	
	2531	−10.8	14.18	13.23	−23.8	− 9.8	2.9	15.5		42.6	
	2532	−21.7	14.22	13.27	−26.5	−12.6	1.8	11.0		39.8	
2329 June 18, '07 10^h02^m	2533	15.1	14.98	14.03	28.8	43.9					
	2534	−17.5	14.42	13.47	−23.7	− 9.2					
	2535	−18.7	13.92	12.97	−14.5	0.0	11.5		37.1		
	2536	−13.0	14.18	13.23	−15.0	− 0.7	11.1				

TABLE I (Continued)

Event Number and Date	Number	Latitude	Period of Motion: Sidereal	Synodic	Longitude Differences Observed: 1	2	3	4	5	6	7
[illegible]	[illegible]	−15°4	14°01	13°06	−17°3	− 3°7	8°5				
	2538	15 9	14 51	13 56	− 7.2	7.4					
	2539	[illegible]	[illegible]	12.70	−14 1	− 1.0	11.0				
	[illegible]	3 1	[illegible]	12 63	−38.9	−25.3					
	2541	5.5	14 17	13.22	−43 5	−29.3	−17.4				
	2542	−11.4	15 00	14.05	−41 5	−26.3	−13.7				
2333	2518	[illegible]	14 31	13 26	20 0	31.9					
[illegible]	[illegible]	−10 9	13 93	12.98	− 2.5	9.8		35 2			
14[illegible]	[illegible]	−18 6	14.32	13.37	− 6.7	5.3					
	[illegible]	−13 0	14.85	13.90	7.6	19.6		47.7			
	[illegible]	−11 0	14 66	13.71	−29 0	−16.7					
	[illegible]	−12 9	14 55	13.60	−30 5	−18 3					
	[illegible]	−12 5	14.55	13 60	−32 2	−20.0					
	[illegible]	1 9	14.77	13.82	−31.7	−19 3					
[illegible] June 20, '07 [illegible]											
2339 June 22, '07 [illegible]	2552	−19 4	14 55	13 60	−27 0		0.5				
[illegible] June 24, '07 [illegible]											
2352 June 26, '07 [illegible]	2553	12 9	14 20	13 25	− 1.3	10.1	24.0	37.2			
	2554	14.3	13.94	12.99	22 0	33.7					
	[illegible]	−26 2	[illegible]	13.29	15.7	27.1	41 5				
	[illegible]	−15.1	14 99	14.04	14.6	27.3	41.9				
	2557	−10 2	15.04	[illegible]	11 1	23 2	37.8	52 1			
	[illegible]	−21.8	14 27	13 32	0 3	12.2	26 2				
	2559	−18 7	15 16	14.21	1 6	8.2					
	2560	−16 8	15 22	14 27	− 2.9	9.3	24.8				
	2561	−21 1	14 27	13 32	− 8.7	3.3					
	[illegible]	−15 8	13 76	12.81	− 7.9	3.6	17.0				
	2563	−12 5	15 38	14.43	1.5	14.5					
	[illegible]	[illegible]	14 27	13 32	− 7.1	4.9					
	2565	− 5 0	14 43	13 48	5.7	17.7	31.9				
	[illegible]	− 1.5	14 61	13 66	0.7	13 0					
	[illegible]	− 4.7	13 91	12 96	− 5.2	6.2	19 1	32.7			
	[illegible]	12 7	14 25	[illegible]	−10 3	1.4	15 5	28 3			
	[illegible]	14 2	14 32	13 37	−10 1	2.1	15.9				
	2570	15 8	14 45	13 50	−11.9	0 3	14.3	27.3			
	2571	17 5	14 00	13 05	−16.1	− 3.7	9.3				
	2572	25 0	13 72	12 77	−13.7	− 2 2					
	2573	10 8	14 50	[illegible]	−14 2	2 0					
	2574	[illegible]	14 17	13 22	−14.7	− 2.7	11.0				
	2575	16 7	14 38	13 43	−20 3	− 8 2					
	2576	13 2	14 38	13 43	−25.0	−12 9					
	2577	19 3	13 72	12 77	− 9.6	1 9					
	2578	− 7 7	14 58	13 63	−30 8	−18 4	− 4.3				
	2579	−12 0	14 61	13 66	−15.2	− 2.9					
2353	2580	− 5 7	14 56	13 61	− 2 3	11.9					
June 27, '07	2581	− 6 1	14 79	13 84	9 0	23 5	36 8				
[illegible]	2582	[illegible]	14 25	13 30	9 6	23 5	36 3				
	2583	−10 8	14 49	[illegible]	2 6	16 8	[illegible]				
	2584	22 7	13 81	[illegible]	− 4 9	8 3	21 0				
	2585	21 8	13 90	12 95	− 7 7	5 8	18 3				
[illegible]	[illegible]	- 23 6	13 17	12 22	18 3	30 1					
June 28, '07	2587	−21 4	[illegible]	13 88	13 5	26 9					
[illegible]	[illegible]	11 3	15 14	14 19	12 7	[illegible]					
	[illegible]	11 9	14 83	[illegible]	11 0	24 4					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Obs. (1st)						
			Sidereal	Synodic	1	2	3	4	5	6	7
2358 (*cont.*)	2590	15.4	12°86	11°91	4°6	16.1					
	2591	15.8	14.73	13.78	21.2	34.5					
	2592	33.4	14.52	13.57	9.9	23.0					
	2593	38.0	14.21	13.26	14.8	27.6					
	2594	4.8	14.73	13.78	−37.0	23.7					
	2595	−17.4	14.67	13.72	−37.1	−24.1		2°6	16°1	31.5	
	2596	−19.1	14.00	13.05	−31.0	−18.4					
	2597	−23.1	14.42	13.47	−33.5	−20.5					
	2598	−23.4	14.34	13.39	−36.0	−23.0		3.5			
	2599	3.1	14.67	13.72	−30.0	−16.7		10.5	24.3	41.1	
2361 June 29, '07 9^h39^m	2600	−19.9	15.12	14.17	−30.1		− 2°0				
	2601	−21.5	15.07	14.12	−28.7		− 0.7				
2365 July 1, '07 9^h14^m	2602	−18.8	14.82	13.87	0.2	13.5	31.2				
	2603	−15.2	14.65	13.70	0.6	13.5	31.2				
	2604	−12.1	14.12	13.17	− 2.0	11.2					
	2605	−13.0	14.41	13.46	− 6.0	7.1	24.1				
	2606	−14.8	14.65	13.70	− 8.1	4.9	22.5				
	2607	−17.5	15.04	14.09	− 9.8	3.8	21.7				
	2608	−14.2	14.82	13.87	−17.0	− 3.7	14.0				
	2609	−17.0	14.62	13.67	−17.0	− 3.3					
	2610	5.2	15.13	14.18	5.6	19.5	37.3				
	2611	5.2	14.31	13.36	− 1.8	11.8	28.1				
	2612	2.1	14.72	13.77	− 0.5	13.3					
	2613	11.9	15.07	14.12	−43.5	−29.2	−11.9				
	2614	6.5	14.62	13.67	−43.2	−29.5					
2369 July 2, '07 9^h17^m	2615	−21.5	15.03	14.08	11.8	29.2					
	2616	−18.2	14.87	13.92	− 1.9	15.3					
	2617	−20.4	14.71	13.76	19.1	36.1					
	2618	−33.7	14.55	13.60	−20.0	− 3.2					
	2619	−15.7	15.19	14.24	−21.3	− 3.7					
	2620	−18.1	14.71	13.76	−19.1	− 2.1					
	2621	−26.5	15.19	14.24	2.0	19.6					
	2622	−27.3	15.19	14.24	− 0.7	16.9					
	2623	−31.8	14.71	13.76	− 3.8	13.2					
	2624	−34.6	14.71	13.76	−13.1	3.9					
	2625	−38.9	14.71	13.76	−14.0	3.0					
2375 July 3, '07 2^h56^m											
2401 July 26, '07 11^h28^m	2626	−13.4	15.17	14.21	15.5	28.4					
	2627	−10.9	15.72	14.76	16.2	29.6					
	2628	−15.3	15.83	14.87	24.3	37.8					
	2629	−10.8	14.73	13.77	7.6	20.1					
	2630	− 7.8	15.17	14.21	5.6	18.5					
	2631	− 3.2	13.96	13.00	7.4	19.2					
	2632	−10.9	13.63	12.67	1.7	13.2					
	2633	−10.6	14.51	13.55	− 2.5	9.8					
	2634	− 8.9	15.06	14.10	−12.8	0.0					
	2635	16.9	15.61	14.65	5.5	18.8					
	2636	18.2	14.51	13.55	19.7	32.0					
	2637	20.9	14.18	13.22	19.9	31.9					
	2638	23.8	14.51	13.55	21.6	33.9					
	2639	0.7	14.40	13.44	−11.3	0.9					
	2640	7.8	14.50	13.54	−38.0	−25.4		1.3	14.8	30.0	43.5
	2641	9.8	14.84	13.88	−40.5	−27.9					
	2642	− 3.2	13.74	12.78	5.3	16.9					
	2643	6.3	15.17	14.21	−11.9	1.0					
2403 July 27, '07 9^h15^m	2644	−29.6	13.96	13.00	−25.0		0.6	14.1	27.0	41.8	

TABLE I—Continued

Plate, Exposure and Date	No.	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
2406	2645	−28°0	14°06	13°10	4.9	17°2	32°2				
July 29, '07	2646	−29 6	14 34	13 38	2 1	18 3	33 0				
9h45m	2647	−15 6	15 14	14 18	2 5	16 3					
	2648	−12 1	14 92	13 96	1.7	15 5	30 8				
	2649	−32 2	13 48	12 52	− 1.1	11.5	25 0				
	2650	2 4	14 32	13 36	24.7	37.7					
	2651	6 7	13 81	12 85	26 8	39 3					
	2652	−14 8	14 53	13 57	12 8	26 0					
	2653	10 8	14 70	13 74	− 9.0	4.8	19 9	33°4			
	2654	8 4	14 67	13 71	− 8.4	4 5	20 1	33.7			
	2655	9 9	14 55	13 59	− 4.6	8 3	23.3	37.0			
	2656	4 9	14 66	13 70	− 0.4	7 3	22 3	35.9			
	2657	3 4	14 05	13 09	− 0.9	11 4	26 4				
	2658	1 3	14 72	13 76	− 1.9	11 8	26.8				
	2659	5 7	14 42	13 46	1 6	14.7					
	2660	− 8 9	14 01	13 05	− 4.8	7.9					
	2661	8 6	14 53	13 57	−39 1	−25 9					
	2662	− 0 2	14 84	13 88	−39.7	−26 2					
	2663	4 6	13 63	12 67	−38 4	−26 2	−12 0				
	2664	22 4	13 92	12 96	−36 2	−23 6	− 9.2				
	2665	14.7	14 01	13 05	−10 4	12 2	26.7	39.8			
2411	2666	7.9	15 40	14.44	1.3	17.0	30.9	42.8			
July 30, '07	2668	0 4	14.73	13 77	−29 0	−13.7					
9h18m	2669	5 8	14 90	13 94	10 8	26.2	40 2				
	2670	7 8	14 72	13 76	8.8	24.1	37.8				
	2671	2 0	14 16	13 20	−35 2	−20.7	− 7.3	5.2	17°7		
	2672	4 2	14 38	13 42	−39 8	−25.1	−11 6	1.0	14.1		
	2673	9 6	14 32	13 53	−31.6	−16.1	− 3.2	11 1	22.3		
	2674	6 7	14 38	13 62	−33 0	−17 9	− 5.1	8.7			
	2675	1 8	14 48	13 52	−32 1	−17.0	− 3.6				
	2676	− 3 3	14 23	13 27	−36 8	−23.1	− 9.1	3.5	16.1		
2417	2677	−13 9	14 60	13 64	28 5	42 1					
July 31, '07	2679	− 6 0	14 39	13 54	19 5	3 0					
11h8m	2680	− 6 8	14 74	13 78	−29 7	−16 0	− 2.7	10.3			
	2681	− 1 4	14 17	13 21	−11 4	−21 0	− 8.5	4.6			
	2682	− 5 7	14 85	13 89	−34 0	−20 3	− 6.9	6.3			
	2683	−12 2	14 40	13 44	−38 1	−24 7					
	2684	− 7 8	14 74	13 78	−40 2	−27.0	−13.6				
	2685	9 2	13 95	12 99	−25 9	−12.9	− 1.0	12.0			
	2686	8 5	14 33	13 37	−32 2	−18.9	− 6.4				
	2687	4 6	14 32	13 36	−31 3	−18.1	− 6.1	6.8			
	2688	3 6	14 08	13 14	−26 9	−13 4					
2420	2678	1 1	14 18	13 22	−11 0	1 6	14 9				
Aug. 1, '07	2690	− 2	14 20	13 57	− 9 8	3.3	16.2				
11h2m	2691	−11	14 84	13 88	−28 5	−15 8	− 2 3				
	2692	−13	14 31	13 31	−31 4	−18.8	− 5.9				
	2693	− 9	14 29	13 73	−24 4	−11 6					
	2695	− 13	14 14	13 18	−21 6	− 8 6	4.8				
	2694	−19 2	15 34	14 38	21 8	35 2					
	2696	10 7	14 59	13 63	−19 6	− 6.9					
2434	2700	5	14 88	13 92	− 4 0	8 8					
Aug. 2, '07	2697	14 5	14 28	13 32	− 5 3	7 9					
10h34m	2698	8 9	14 28	13 32	−21 0	− 7 8					
	2699	− 6 0	15 36	14 40	− 8 4	− 5 6					
	2701	11	14 28	13 31	12 0	26 2					
	2702	− 3	14 35	13 39	−12 8	4 1					
	2703	2 9	14 29	13 33	−11 5	1 0					
2427											
[illegible]											

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
2434	2704	4.1	14°.43	13.47	30°.9	46°.2					
Aug. 9, '07	2705	9.5	14.50	14.54	13.2	28.3					
9h08m	2706	12.6	14.41	13.45	11.9	26.9					
	2707	18.2	14.68	13.72	3.8	19.1					
	2708	−15.6	14.41	13.45	−17.4	− 2.4					
	2709	16.0	14.68	13.72	−20.0	− 4.7					
	2710	−13.3	14.14	13.18	−27.3	−12.6					
	2711	−14.4	14.77	13.81	−32.5	−17.1					
	2712	−11.8	14.43	13.47	−40.7	−25.3		0°.8	13°.7	26°.9	
	2713	−17.4	14.14	13.18	−26.1	−11.4					
	2714	− 8.5	14.32	13.36	−34.8	−19.9					
	2715	− 9.9	14.05	13.09	−27.9	−13.3					
	2713′	−11.7	14.59	13.63	−36.4	−21.2					
2451											
Aug. 10, '07											
11h54m											
2452	2716	−12.8	14.61	13.64	18.0	31.9	45°.2				
Aug. 12, '07	2717	− 9.1	14.52	13.55	3.9	17.1					
10h00m	2718	−11.0	14.52	13.55	− 5.2	7.9	21.8				
	2719	− 3.5	14.87	13.90	− 8.0	5.0	19.7				
	2720	−13.9	15.02	14.05	− 4.8	9.3	23.2				
	2721	−15.7	14.62	13.65	6.0	19.3					
	2722	−15.8	15.03	14.06	14.9	28.6					
	2723	−13.5	14.83	13.86	13.1	26.6					
	2724	−17.4	15.96	14.99	24.1	38.7					
	2725	− 5.6	14.82	13.85	− 2.1	11.2	25.5				
	2726	− 3.4	14.17	13.20	−15.0	− 1.8	11.5		38.4		
	2727	13.4	14.11	13.14	−41.0	−28.2					
2457	2728	14.4	14.04	13.07	−32.0	−18.3		8.1			
Aug. 13, '07	2729	17.7	14.32	13.35	−31.1	−17.5					
9h23m	2730	15.3	14.25	13.28	−35.0	−21.1		5.4	19.8		
	2731	− 0.6	14.81	13.84	−12.9	1.2					
	2732	− 6.7	14.15	13.18	−11.9	1.3		27.9	42.3		
	2733	− 8.4	14.52	13.55	−11.8	2.0					
	2734	− 8.6	14.48	13.51	− 8.8	5.1		32.6			
	2735	− 2.1	13.89	12.92	− 3.1	9.7		36.4			
	2736	−23.0	14.71	13.74	− 1.8	12.2					
	2737	−12.6	13.53	12.56	− 4.7	8.1					
	2739	− 7.1	13.93	12.96	3.9	17.1					
	2740	− 8.2	14.71	13.74	5.3	19.3					
	2741	−19.1	14.07	13.10	−22.0	− 8.3		18.2			
	2742	−22.3	14.03	13.06	−25.5	−12.2					
	2743	−20.6	14.28	13.31	−20.7	− 7.0		20.1			
	2725′	−10.2	14.42	13.45	9.7	23.4					
2460	2744	− 6.8	14.72	13.75	7.2		35.3				
Aug. 14, '07	2745	−24.6	14.62	13.65	− 8.2		20.0	33.8			
9h50m	2746	−21.1	14.19	13.22	−16.5		10.7	24.2			
	2747	14.5	14.06	13.09	−25.3		1.2	15.1			
2465	2748	−15.2	13.87	12.90	20.1	33.5					
Aug. 16, '07	2749	21.8	13.77	12.80	− 9.2	4.1					
10h53m	2750	20.0	13.39	12.42	− 9.1	3.8					
	2751	19.8	13.58	12.61	−12.0	1.1					
	2752	15.8	14.25	13.28	3.7	17.5					
	2753	−19.0	14.06	13.09	−35.5	−21.9					
	2754	−21.0	13.87	12.90	14.9	28.3					
2468											
Aug. 17, '07											
11h49m											

TABLE I (Continued)

Plate Number and Date	Numbers	Latitude	Residual Motion		Longitudes from Date of Observation						
			Sidereal	Solar	1	2	3	4	5	6	7
2479	2775	−16.9	15.39	12.39	17°8	30°1	42°1				
Aug. 22, '07	2776	− 7.2	15.19	13.22	18.7	32.2	46.5				
10h11m	2777	− 7.2	14.93	13.96	16.0	29.3	43.3				
	2778	−11.3	14.88	13.91	15.5	29.2	42.7				
	2779	−13.8	14.68	13.71	13.2	26.3	40.0				
	2780	−14.7	14.16	13.19	10.2	23.1	36.0				
	2781	−14.2	14.52	13.55	4.0	17.2	30.5				
	2782	−11.5	14.63	13.66	3.0	16.3					
	2783	−12.7	15.35	14.38	− 1.5	12.5					
	2784	4.1	14.68	13.71	−13.0	0.0	13.8				
	2785	10.5	14.47	13.50	−10.1	3.0	16.3				
	2786	− 5.5	14.67	13.70	16.5	30.0	43.3				
	2787	12.0	14.78	13.81	−33.1	−19.9	− 6.1				
	2788	7.4	14.62	13.65	−34.8	−21.7	− 8.1				
	2789	6.9	14.52	13.55	−37.5	−24.3	−11.0				
	2770	1.4	14.01	13.04	−36.1	−23.4	−10.6				
	2771	− 8.0	14.94	13.97	−34.4	−20.8					
	2772	13.0	14.83	13.86	−40.2	−27.0	−13.1				
	2773	10.9	14.78	13.81	−36.2	−23.2	− 9.2				
	2774	4.8	14.11	13.14	−30.5	−17.8	− 4.8				
2477	2775	1.1	15.23	14.26	−14.4	− 0.4					
Aug. 23, '07	2776	6.1	14.41	13.44	−20.1	− 6.9					
9h43m	2777	− 8.1	14.11	13.14	−18.9	6.0					
	2778	−15.6	14.11	13.14	−25.2	−12.3					
	2779	−15.8	14.41	13.44	−27.5	−14.3					
	2780	−12.3	14.31	14.34	−26.7	−13.6					
	2781	−14.3	13.39	12.42	−22.2	−10.0					
	2782	−14.8	14.41	13.44	31.4	44.6					
	2783	8.9	15.43	14.46	−30.9	−16.7					
	2784	11.0	14.92	13.95	−25.0	−11.3					
2480											
Aug. 24, '07											
9h07m											
2501	2785	−10.4	14.10	13.12	16.4	29.4					
Sept. 12, '07	2786	−10.2	14.83	13.85	12.1	25.4	39.2				
10h48m	2787	−12.6	14.21	13.23	8.4	21.0	34.3				
	2788	−20.8	14.98	14.00	6.5	20.1	33.9				
	2789	− 7.0	13.59	12.61	31.2	43.7					
	2790	−10.0	14.00	13.02	32.0	44.9					
	2791	17.9	14.40	13.42	15.0	28.3					
	2792	15.7	14.30	13.32	14.5	27.7					
	2793	14.2	14.26	13.28	10.0	22.7	36.0				
	2794	11.7	15.11	14.13	10.9	24.9					
	2795	11.3	14.52	13.54	8.8	21.9	35.3				
	2796	16.0	14.27	13.29	8.0	21.0	34.0				
	2797	17.7	15.11	14.13	0.5	14.8					
	2798	17.9	14.88	13.90	− 1.2	12.2	26.0				
	2799	9.0	14.10	13.12	−14.9	− 1.9					
	2800	7.8	14.30	13.32	−18.2	− 5.0					
	2801	10.0	14.47	13.49	−19.4	− 6.1	7.0				
	2802	8.0	14.40	13.42	−22.2	− 8.9					
	2803	12.6	14.50	13.52	−22.2	− 8.8					
	2804	10.0	14.62	13.64	−21.9	− 8.8	4.8				
	2805	19.3	14.88	13.90	−10.0	3.7	17.2				
	2806	19.0	14.88	13.91	− 9.7	3.8	17.5				
	2807	− 1.9	15.03	14.03	9.9	23.7	37.4				
	2808	− 8.0	14.72	13.74	17.0	30.8	43.5				
2487	2809	0.4	14.06	13.08	1.3	11.8					
Sept. 13, '07	2810	0.4	15.06	14.08	20.4	34.0					
10h55m	2811	− 0.5	14.83	13.86	16.0	29.4					
	2812	1.3	14.99	14.01	14.1	26.8					
	2813	− 4.2	14.23	13.25	13.3	26.1					
	2814	− 7.0	14.36	13.38	8.3	21.3					
	2815	− 9.1	15.27	14.29	7	0					

TABLE I *Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
2505 (*cont.*)	2816	−21°.7	14°.33	13°.35	−29°.9	−17°.0					
	2817	−21.3	14.23	13.25	−25.8	−13.0					
	2818	−17.4	14.13	13.15	−24.2	−11.5					
2509 Sept. 14, '07 9^h16^m											
2538*a* Oct. 8, '07 9^h32^m	2819	13.6	14.12	13.13	22.7	36.3					
	2820	14.9	14.41	13.42	24.3	38.2					
	2821	15.4	14.51	13.52	− 6.8	7.2					
	2822	21.1	13.64	12.65	− 7.1	6.0					
	2823	3.8	15.09	14.10	− 7.6	7.0					
	2824	− 1.3	14.90	13.91	− 7.5	6.9					
	2825	− 5.3	13.55	12.56	− 7.5	5.5					
	2826	− 8.1	14.22	13.23	− 4.2	9.5					
	2827	− 5.9	14.61	13.62	− 4.6	9.5					
	2828	− 4.0	14.02	13.03	1.2	14.7					
	2829	− 7.9	14.51	13.52	0.2	14.2					
	2830	−12.7	13.74	12.75	3.8	17.0					
	2831	−12.2	14.32	13.33	20.6	34.4					
	2832	−15.4	14.32	13.33	21.5	35.3					
	2833	− 0.1	15.28	14.29	27.0	41.8					
	2834	− 1.5	14.90	13.91	23.4	37.8					
2542 Oct. 9,' 07 10^h23^m											
2551 Oct. 17, '07 11^h05^m	2835	11.9	14.42	13.43	12.9	25.8					
	2836	12.1	14.01	13.02	21.4	33.9					
	2837	15.7	14.84	13.85	29.7	43.0					
	2838	16.5	14.11	13.12	25.5	38.1					
	2839	23.8	13.69	12.70	23.8	36.0					
	2840	− 4.7	14.63	13.64	24.2	37.3					
	2841	− 0.2	14.53	13.54	27.7	40.7					
	2842	− 0.9	15.05	14.06	24.3	37.8					
	2843	− 6.6	13.69	12.70	− 6.2	6.0					
	2844	10.8	14.63	13.64	−18.1	− 5.0					
	2845	12.2	14.42	13.43	−20.1	− 7.2					
	2846	7.8	14.21	13.22	−21.7	− 9.0					
	2847	6.0	14.63	13.64	−19.7	− 6.6					
	2848	10.3	15.15	14.16	−25.8	−12.2					
	2849	1.2	14.42	13.43	−24.0	−11.1					
	2850	1.4	14.73	13.74	−28.2	−15.0					
	2851	11.6	14.42	13.43	−30.9	−18.0					
2554 Oct. 18, '07 10^h08^m											
2557 Oct. 21, '07 10^h33^m2	2851′	2.1	15.51	14.51	25.5	40.0					
	2852	3.8	15.01	14.01	24.5	38.5					
	2853	5.6	14.71	13.71	21.9	35.6					
	2854	0.8	14.67	13.67	17.4	31.2	45°.0				
	2855	8.0	14.71	13.71	25.4	39.1					
	2856	10.3	15.21	14.21	25.3	39.5					
	2857	6.6	14.92	13.92	18.1	32.9	46.2				
	2858	11.5	14.33	13.33	21.8	34.8	48.7				
	2859	13.3	14.77	13.77	14.2	28.0	42.0				
	2860	11.9	13.78	12.78	4.7	17.7	30.5				
	2861	4.9	14.71	13.71	5.2	18.9					
	2862	0.4	13.93	12.93	6.6	19.9	32.7				
	2863	9.1	14.57	13.57	5.3	19.1	32.7				

TABLE I (*continued*)

Preceding Normal Date	No.	Longitude	Distance Normal		Latitudes of Disturbed Meridians						
			Solodic	Synodic	1	2	3	4	5	6	7
2557 (*cont.*)	2864	5°.5	14°.52	13°.52	− 2°.1	16°.9	29°.4				
	2865	9 7	14 52	13 52	− 2 4	16 0	29 7				
	2866	13 3	14 33	13 33	− 3.1	10 4	23 8				
	2867	6 7	13 88	12 88	−10 6	2 2	15 4				
	2868	3 4	14 71	13 71	− 8.7	5 0					
	2869	− 3 6	14 13	13 13	− 6.3	7 5	20 2				
	2870	10 9	14.28	13 28	−16.0	− 2.7	10 8				
	2871	13 0	14 61	13 61	−14 1	− 0 5					
	2872	18 1	12 81	11 81	−23 3	−11 5					
	2873	7 4	14 41	13 41	− 7.2	6 2					
	2874	14 0	14 71	13.71	0 2	13 9					
	2875	12 2	14 71	13 71	1 0	14 7					
	2876	4 5	14 62	13 62	16 9	30 7	44 4				
	2877	− 22 5	14 47	13 47	14 8	38 5	42 0				
	2878	−19 9	14 51	13 51	14.5	28 0					
	2879	−26 4	14 31	13 31	3.7	17 0					
	2880	−28 8	15 21	14 21	5.8	20 0					
	2881	−23 3	14 37	13 37	6.5	20 3	34 5				
	2882	−16 9	15 21	14 21	− 8.5	5.7					
	2883	−16 4	14 21	13 21	−12 5	0.7					
	2884	−18 3	15 01	14 01	−19 8	− 5.8					
	2885	−22 7	13 91	12 91	−10 3	2 6					
	2886	−24 0	14 81	13 81	− 7.9	5 9					
	2887	−29 7	14 51	13 51	−13.0	0 5					
	2888	− 9 9	14 92	13 92	−36 1	−21 9	8 0				
	2889	− 5 2	14 11	13 11	−35 1	−22 0					
	2890	1 2	13 71	12 71	−27.9	−15 2					
	2891	6 7	14 51	13 51	13 0	26 5					
	2892	7 0	14 62	13 62	3.5	17 3	31 0				
2560 Oct. 22, '07 19h 2m	2893	4 3	14 93	13 93	24 1	38 3					
	2894	12 0	14 93	13 93	23 9	37 8					
	2895	12 1	13 75	12 75	21 2	34 2					
	2896	11 9	14.54	13 54	9 9	23 7					
	2897	15 6	14.14	13.14	1 2	14 6					
	2898	− 8 9	14 93	13 93	−27.2	−13 0					
	2899	10 8	14 47	13 47	−37 1	−23 0		3°.0			
	2900	4 8	13 85	12 85	−13 8	− 0 7					
	2901	3 7	14 63	13 63	−16 2	− 2.3					
	2902	11 4	13 95	12 95	−11 0	2 2					
2564 Oct. 23, '07 11h 9m	2903	10 0	14 37	13 37	−11 0		15 1				
	2904	10 6	14 58	13 58	− 8 9		17 6				
	2905	−19 5	14 06	13 06	−30 3		− 4.8				
	2906	7 9	14 01	13 01	−22 7		2 7				
	2907	5 2	14 58	13 58	−29 0		− 2 5				
	2908	8 2	14 27	13 27	−27 2		− 1.3				
	2909	2 8	14 01	13 01	−32 2		− 6 8				
	2910	7 0	14 42	13 42	−25 8		0 4				
2568 Oct. 25, '07 7h 5m											
[illegible]	2911	−18 2	14 88	13 87	[illegible]	47 8					
[illegible]	2912	−15 4	14 49	13 48	31 8	48 4					
	2913	−19 5	14 06	13 06	11 7	26 5					
	2914	−17 1	15 48	14 48	17 1	26 9					
	2915	−12 1	14 59	13 58	37 5	51 2					
	2916	− 8 2	14 19	13 18	−25 3	−12 0					
	2917	− 9 4	14 06	13 58	−28 0	−14 3					
	2918	− 3 5	13 78	12 78	30 1	46 8					
	2919	0 7	14 98	13 97	28 6	44 [illegible]					
	2920	[illegible]	14 69	13 68	−20 2	[illegible]					
	2921	− 6 2	14 39	13 38	−28 9	0 1					
	2922	[illegible]	14 39	13 38	−36 2	− 22 7					
	2923	[illegible]	14 06	13 06	[illegible]	14 [illegible]					
	2924	17 0	14 10	14 09	[illegible]	19 [illegible]					
	2925	0 1	14 58	14 57	0 [illegible]	− 3 1					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
2620 Dec. 20, '07 11^h36^m											
2682 Apr. 20, '08 10^h13^m	2927	− 6°6	14°80	13°83	24°2	38°0					
	2928	− 7.4	14.60	13.63	33.4	47.0					
	2929	− 9.2	14.40	13.43	31.6	48.0					
	2930	−17.3	14.09	13.12	15.0	28.5	43.8				
	2931	−18.9	14.33	13.36	18.8	32.1	48.1				
	2932	−16.2	14.50	13.53	18.0	31.5					
	2933	−21.9	14.04	13.07	18.3	31.9	47.0				
	2934	−10.8	14.75	13.78	−19.9	− 6.5	10.3				
	2935	−10.9	14.50	13.53	−22.0	− 8.5					
	2936	−13.4	13.00	12.03	−26.9	−14.9					
	2937	−27.9	14.00	13.03	−18.8	− 5.8					
	2938	−10.7	14.60	13.63	−33.9	−20.3					
	2939	−19.2	14.20	13.23	11.9	25.1					
2685 Apr. 21, '08 10^h10^m	2942	−19.1	13.93	12.96	30.2	45.7					
	2943	−15.3	14.02	13.05	−18.1	− 2.5					
	2944	−12.3	14.85	13.88	−19.4	− 2.8					
	2945	−12.2	14.60	13.63	− 6.8	9.5					
	2946	− 5.7	14.43	13.46	−31.0	−14.9					
	2947	− 0.4	14.52	13.55	−30.5	−14.3					
	2948	2.5	14.18	13.21	−24.1	− 8.3					
	2949	2.3	14.43	13.46	−30.8	−14.7					
	2950	10.5	14.18	13.21	−35.4	−19.6					
	2951	− 4.0	14.35	13.38	−29.0	−13.0					
2689 Apr. 22, '08 2^h52^m											
2702 May 20, '08 10^h04^m	2953	9.0	13.45	12.49	20.6	33.3					
	2954	12.9	13.99	13.03	14.1	27.4	40.5				
	2955	15.9	14.93	13.97	12.1	26.3					
	2956	15.5	14.73	13.77	10.0	24.0					
	2957	6.4	14.98	14.02	17.3	31.9	45.7				
	2958	−14.1	13.55	12.59	24.2	37.0					
	2959	12.2	14.24	13.28	−16.6	− 2.9	10.3				
	2960	9.7	14.37	13.41	−17.9	− 4.3	9.5				
	2961	7.7	14.88	13.92	−17.9	− 3.8	10.3				
	2962	−10.3	13.94	12.98	−14.3	− 1.0	12.0				
	2963	− 7.0	14.44	13.48	−24.0	−10.3					
	2964	− 7.9	13.84	12.88	−22.3	− 8.9	3.8				
	2966	−12.8	14.33	13.37	−29.4	−15.7	− 2.3				
	2967	− 9.1	14.04	13.08	−33.0	−20.0	− 6.5				
	2968	6.3	14.14	13.18	−38.5	−25.1					
	2969	8.7	14.44	13.48	−41.5	−27.8					
	2970	− 4.6	15.03	14.07	−11.7	2.6					
	2971	− 3.1	15.12	14.16	− 4.7	9.9	24.0				
	2972	1.5	15.03	14.07	− 0.9	13.4					
	2973	11.9	14.81	13.85	− 4.1	10.3	24.2				
	2974	−15.9	14.73	13.77	− 3.9	10.4	24.0				
2705 May 21,' 08 10^h28^m	2975	−15.0	14.13	13.17	12.0	25.3					
	2976	−12.8	15.22	14.26	14.5	28.9					
	2977	9.6	14.53	13.57	26.3	40.0					
	2978	10.4	14.23	13.27	30.3	43.7					
	2979	6.0	13.74	12.78	24.0	36.9					
	2980	8.4	13.93	12.97	23.8	36.9					
	2981	−12.8	14.13	13.17	−14.1	− 0.8					
	2981′	−16.5	14.13	13.17	20.4	33.7					
2709 May 22, '08 10^h42^m											

TABLE I—(Continued)

Plate Number and Date	Number	Position	Diurnal Motion		Excesses of Days of Observation						
			Stars	Stars	1	2	3	4	5	6	7
2714	2982	8 6	14°51	13°56	12°0	25°8					
June 1, '08	2983	7 5	14 89	13 82	8 6	23 0					
9 18	2984	7 3	14 92	12 97	5 1	18 3					
	2985	- 8 1	14 31	13 36	27 2	40 8					
	2986	-12 0	15 09	14 14	24 3	38 7					
	2987	-15 3	14 60	13 65	22 8	36 7					
	2988	-15 4	14 80	13 85	16 0	30 1					
	2989	-11 2	14 21	13 26	12 9	26 4					
	2990	- 8 5	14 11	13 16	14 9	28 5					
	2991	- 5 7	14 60	13 65	18 9	32 8					
	2992	- 4 2	15 39	14 44	12 9	27 6					
	2993	- 6 8	15 00	14 05	9 8	24 1					
	2994	- 8 2	15 09	14 14	7 8	22 2					
	2995	-13 9	14 37	13 42	8 1	21 9		48 5			
	2996	-17 3	14 08	13 13	4 0	18 0		43 6			
	2997	-23 9	14 41	13 46	7 3	21 0					
	2998	-18 6	13 62	12 67	- 0 9	12 0					
	2999	7 5	14 70	13 75	- 8 7	5 3					
	3000	- 6 5	14 36	13 41	-10 3	3 2		30 0			
	3001	- 4 6	14 41	13 46	-12 1	1 6					
	3002	- 0 1	14 91	13 96	-13 7	0 6		28 3			
	3003	1 3	14 11	13 16	-15 1	- 1 7					
	3004	- 4 1	14 61	13 66	-16 9	- 1 9		24 8	38°4		
	3005	- 5 7	14 80	13 85	-16 8	- 2 7					
	3006	- 7 4	14 80	13 85	-18 6	- 4 5					
	3007	- 5 2	14 71	13 76	-19 8	- 5 4		21 3	36 0		
	3008	- 1 6	14 60	13 65	-20 0	- 6 1					
	3009	- 3 8	14 94	13 99	-26 7	-12 7		14 7	29 7	45 7	
	3010	-10 0	14 23	13 28	-24 0	-10 2		16 0			
2719	3011	7 6	14 46	13 51	3 8		29 9	44 7			
June 2, '08											
9 44											
2725	3012	8 7	15 21	14 26	5 7	8 9					
June 4, '08	3013	−5.9	14 14	13 19	27 0	40.5					
9 29	3014	10 2	13 85	12 90	27 8	41 0					
	3015	9 9	14 63	13 68	11 2	2 8					
	3016	10 7	14 80	13 85	15 2	- 1 1	12 9				
	3017	− 8 2	14 65	13 70	-10 0	4 0	17 8				
	3018	−14 9	13 77	12 82	-15 9	2 8	10 1				
	3019	9 9	14 16	13 21	-24 3	- 9 5	3 5				
	3021	8 0	14 51	13 56	-21 2	- 7 9	6 3				
	3022	7 1	14 85	13 90	-17 0	- 3 4	11 2				
	3023	10 1	14 92	13 97	-34 6	-20 4					
	3024	−12 6	14 56	13 61	-43 1	−29 1	−15.5				
2730	3025	− 9 9	14 58	13 63	29 2	42 9					
June 7, '08	3026	−13 1	13 59	12 64	18 4	31 1					
10 03	3027	11.4	14 98	14 03	5 4	19 5					
	3028	9 8	15 08	14 13	1 3	15 5					
	3029	7 5	13 89	12 94	-12 0	1 0					
	3030	13 2	14 78	13 83	-21 7	- 7 8					
	3031	12 4	13 49	12 54	-25 3	-12 7					
	3032	12 6	13 49	12 54	-27 2	-14 6					
	3033	11 3	13 99	13 04	-32 1	-19 0					
	3034	9 8	14 68	13 73	-30 2	-16 4					
	3035	−16 9	14 38	13 43	-43 5	-30 0					
	3036	−10 1	14 68	13 73	7 4	21 2					
	3037	9 1	13 59	12 64	7 0	19 7					
	3038	13 9	13 89	12 94	- 3 7	9 3					
2735											
June 11, '08											
10 00											
2745	3040	13 6	15 80	14 85	13 7	32 6					
June 13, '08	3041	12 5	15 49	14 54	8 9	28					
9 59	3042	10 4	16 11	15 16	13 7	25 7					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
2748 (*cont.*)	3043	9°4	14°73	13°78	10°0	22°9					
	3044	11.0	13.98	13 03	10 6	22.8					
	3045	12 5	14.84	13.89	6 5	19.5					
	3046	9.3	14.30	13.35	4.3	16.8					
	3047	10.3	13.98	13 03	0.0	12 2					
	3048	8.5	14.41	13.46	− 1.0	11 6					
	3049	6.1	13.98	13 03	− 5.9	6.3					
	3050	17.0	14.20	13.25	−18.0	− 5.6					
2753 June 16, '08 10^h12^m2											
2768 June 24, '08 9^h55^m3	3051	− 2.6	14.93	13.98	36 0	50.0					
	3052	3.2	14.63	13.68	30.5	44 2					
	3053	6.9	14.63	13.68	31.1	44.8					
	3054	10.8	13.94	12.99	29.2	42.2					
	3055	−19.1	15.73	14.78	22.4	37.2					
	3056	−20.0	14.33	13.38	20.7	35.1					
	3057	−15.3	14.19	13.24	14.3	27.8	40°5				
	3058	−22.6	13.78	12.83	11.2	24.5	36 6				
	3059	−23.5	15.13	14.18	14.0	28.2					
	3060	−19.8	15.13	14 18	18.6	32.8					
	3061	−18.3	14.03	13.08	4.8	17.6	30.7				
	3062	−21.5	14.89	13.94	0.0	13.8	27.6	41°2			
	3063	−24.5	14.93	13.98	1.6	15.6					
	3064	−21.9	15.15	14.20	− 5.6	9.2	22.5				
	3065	−19.7	14.93	13.98	− 8.0	6.0					
	3066	−22.7	14.54	13.59	− 8.7	5.8	18.2				
	3067	−26.1	15.23	14.28	−11.0	3.3					
2774 June 25, '08 9^h56^m9	3068	3.8	14.22	13.27	−35.3	−22.5	− 9.3				
	3069	3.8	14.54	13.59	−31.3	−18.0					
	3070	9.8	15.36	14.41	−21.3	− 7.2					
2781 June 26, '08 9^h26^m0	3072	−24.5	14°11	13.16	23.1	36.0					
	3073	−20.0	15.23	14.28	15.3	29.3					
	3074	−16.8	13.70	12.75	11.7	24.2					
	3075	−20.4	14.72	13.77	19.1	32.6					
	3075′	−19.7	14.92	13.97	17.4	31.1					
	3076	−25.7	13.19	12.24	9.7	21.7					
	3077	−18.0	14.31	13.36	− 4.6	8.5					
	3078	−19.9	15.13	14.18	− 6.9	7.0					
	3079	−11.4	14.41	13.46	− 7.0	6.2					
	3080	−10.7	15.64	14.69	1.4	15.8					
	3081	− 6.7	14.72	13.77	−10.9	2.6					
	3082	− 5.5	14.52	13.57	−15.3	− 2.0					
	3083	0.9	14.82	13.87	−13.5	0.1					
	3084	−11.9	14.52	13.57	−18.5	− 5.2					
	3085	−16.8	14.31	13.36	−20.1	− 7.0					
	3086	−16.2	14.31	13.36	−26.1	−13.0					
	3087	− 6.3	14.41	13.46	−24.3	−11.1					
	3088	− 4.6	14.62	13.67	−22.4	− 9.0					
	3089	− 4.4	14.01	13.06	−26.3	−13.5					
	3090	− 2.3	15.03	14.08	−34.8	−21.0					
	3091	− 9.7	14.62	13.67	−45.5	−32.1					
	3092	9.3	15.03	14.08	− 8.2	5.6					
	3093	−11.2	14.41	13.46	−32.0	−18.8					
	3094	− 0.2	14.62	13.67	−40.7	−27.3					
2789 June 27, '08 8^h57^m7											
2805 July 8, '08 9^h21^m	3097	−12.0	14.64	13.69	14.1	27.8	44.3				
	3098	− 8.9	14.45	13.50	10.4	24.1	40.1	51.8			
	3099	−21.6	14.50	13.55	− 3.0	10.7	26.9				

TABLE I (Continued)

Plate Number and Date	Number	Latitude	Diurnal Motions		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
2805	3100	−21.2	14°24	13°29	− 8.5	4°5	20°8				
	3101	−21.5	14 60	13 65	−10 3	3 0	19.9	31°3			
	3102	−18 3	14 73	13 78	−11 2	2.0	19 0	30 8			
	3103	−21 6	14 55	13 60	−13 8	− 0.4	16 2				
	3104	−20 7	13 86	12 91	−16 4	− 3.2	12.1				
	3105	−21 0	14 22	13 27	−20.0	− 6.7					
	3106	−18 8	13 82	12 87	−18 1	− 5.2					
	3107	11 6	14.63	13 68	1 2	12.8	29.0				
	3108	14.1	14 95	14 00	6 9	7.5	24.0				
	3109	13.5	14 72	13.77	− 8.5	5.3					
	3110	19.4	14 64	13 69	−12.7	1.3	17.9	29.1			
	3111	16 6	14 16	13 21	−14.3	− 0.2	15.6	26.1			
	3112	14.7	14.82	13 87	−14.4	− 0.5					
	3113	13 4	14 32	13 57	−14 5	− 1.5	15.2	26 9			
	3114	18 5	15 09	14 14	−17.4	− 3.1	13.8				
	3115	16 1	14.49	13 54	−17.0	− 3.0	12.9				
	3116	13.5	14.33	13 38	−16.9	− 3.8	12.6				
	3117	10 8	14 39	13 44	−18 3	− 5.7	11.3				
	3118	11.5	14.78	13 83	−28.5	−15.0	2.0				
	3119	11.8	14.53	13.58	−32 6	−19.9	− 2.7				
2809 July 9, '08 9h23m8	3120	−21.7	15 06	14 11	− 9.5	7.5					
	3121	−22 4	14 22	13 27	− 7.1	9.6	20.1				
	3122	−18 9	14.24	13 29	− 8.0	8.3	19.3				
	3123	9 3	14.48	13.53	−18.3	− 2.0					
	3124	7 1	14.52	13.57	−23.8	− 7.3	4.1				
	3125	− 8.1	15 55	14.61	−27.0	− 9.4					
	3126	− 7.2	14 65	13.70	−24.3	− 7.8					
2813 July 10, '08 2h18m0	3127	11.1	14 68	13.73	26.1	37.8					
	3128	15.0	14.56	13.61	24.8	36.4					
	3129	14 6	14.33	13 38	20 9	32.3					
	3130	15 2	14 21	13 26	23 0	34.3					
	3131	17 0	14 09	13.14	24.0	35.2					
	3132	12 3	14.92	13 97	10 3	22.2					
	3133	9 4	13 98	13 03	15.1	26.2					
	3134	13 5	14 09	13 14	− 3.0	8.2					
	3135	10 6	14 09	13.14	−21.7	10.5					
	3136	6 3	15 62	14 67	−34.8	−22.3					
	3137	6 3	13 86	12 91	−35.2	−24.2					
	3138	8 7	13 98	13 03	23 8	34.9					
2820 July 11, '08 10h45m8											
2824 July 14, '08 14h38m0	3139	0 9	14 51	13 56	− 0 3	13.5					
	3140	1 0	14 61	13 66	1.9	15.8					
	3141	3 7	14 31	13 36	4.3	17.9					
	3143	5 9	13 92	12 97	−12 7	0 5					
	3144	−18 2	14 80	13 85	−16 8	− 2.7					
	3145	−16 6	13 92	12 97	−22 2	− 9.0					
	3146	−18 7	13 72	12 77	−35 6	−22 6					
	3147	−14 3	13 92	12 97	−35 4	−22 2					
	3148	− 9 0	14 12	13 17	−35 5	−22.1					
	3149	− 9 3	14 05	13 07	−46 3	−33 0					
	3150	−23 3	14 31	13 36	− 7.2	6 4					
2837 July 15, '08 10h33m0											
2840 July 21, '08	3151	18 0	14 92	13 97	32 0	45 5					
	3152	−16 0	14 41	13 46	25 1	38 1					
	3153	−16 6	14 39	13 44	21 6	33 5					
	3154	5 3	13 98	12 11	14.9	26.5					

TABLE I *Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
2840 (*cont.*)	3155	−23°4	13°99	13°01	22°7	35°3					
	3156	−12 8	15 13	14.18	12 7	26.4					
	3157	−19.2	14.20	13.25	14.0	26.8					
	3158	−25.5	13.99	13.04	17.4	30 0					
	3159	−23.8	13.37	12.42	15 0	27.0					
	3160	−24.7	12.85	11 90	14.1	25.6					
	3161	−23.3	13.58	12 63	12.3	24.5					
	3162	−19.2	14.10	13.15	7.8	20.5					
	3163	−27.0	14.20	13 25	8.3	20.8					
	3165	−13.1	13 99	13.04	− 6.8	5.8					
	3166	−18.9	13.78	12.83	−11 1	1.3					
	3167	−22.1	13.68	12.73	− 9.0	3.3					
	3168	−20.2	13.27	12.32	−13.1	− 1.2					
	3169	−13.2	13.68	12.73	−12 2	0.1					
	3170	− 7.0	13.06	12.11	−22.5	−10.8					
	3171	− 0.6	13.99	13.04	−16.6	− 4.0					
	3172	−13.8	14.41	13.46	15.8	28.8					
	3173	1.5	13.78	12.83	−36.1	−23.7					
	3174	3.5	13.47	12.52	−35.5	−23.4					
2845											
July 22, '08											
9h27m4											
2862	3175	8.3	15.08	14.12	31.1	45.1					
July 27, '08	3176	11.2	14.88	13.92	25.3	39.1					
9h44m2	3177	2.2	14.78	13.82	25.1	38.8					
	3178	− 2.0	13.77	12.81	30.1	42.8					
	3179	− 4.9	14.58	13.62	25.4	38.9					
	3180	− 9.5	14.48	13.52	14.7	28.1					
	3181	− 7.0	14.44	13.48	9.2	21.6	37°2				
	3182	− 4.2	14.59	13.63	7.6	22.8	36.0				
	3183	3.3	15.08	14.12	10.0	24.0					
	3184	18.3	13.57	12.61	9.3	21.8					
	3185	3.8	14.58	13.62	15.2	28.7					
	3186	−19.3	15.79	14.83	7.3	22.0					
	3187	−15.0	14.18	13.22	− 4.0	9.1					
	3188	−18.8	14.68	13.72	− 3.1	10.5					
	3189	−27.8	14 58	13.62	− 7.0	6.5					
	3190	−26.4	13.94	12.98	−11.8	1.5	15.5		40°9		
	3191	−24.5	15.79	14.83	− 9.8	4.9					
	3192	−24.5	14.06	13.10	−20.7	− 7.1	7.0		32.5		
	3193	−17.0	14.98	14.02	−13.7	0.2					
	3194	−14.4	14.52	13 56	−12.2	1 3	16.0				
	3195	−12.5	14.78	13.82	−14.2	− 0.5					
	3196	−11.7	14.48	13.52	−17.1	− 3.7					
	3197	− 3.7	14.90	13.94	−15.8	− 1.8	13.2				
	3198	12.9	14.98	14.02	−12.1	1.8					
	3199	15.1	14.26	13.30	−34.0	−20.9	− 6.5		19.4	32.5	
	3200	17.2	14.28	13.32	−36.7	−23.4	− 9.0				
	3201	18.5	14.28	13.32	−40.3	−27.1					
	3202	−19.2	14.17	13.21	−35.3	−21.6	7.8				
	3203	−19.2	14.37	13.41	−38.3	−24.5	−10.4				
	3204	−16.6	14.48	13 52	−39.3	−25.9					
2876	3205	−22.4	14.28	13.32	−28.0	−13.5					
July 28, '08	3206	−14.9	14.44	13.48	−17.9	− 3.1		23°1	36.1		
9h31m5	3207	−13.3	14.01	13.05	−10.1	4.1					
	3208	−16.4	14.46	13.50	− 6.8	7.3		34.4			
	3209	32.0	13.18	12.22	−36.0	−22.7					
	3210	14.6	13.94	12.98	−32.0	−17.3		7.8			
2884	3211	15.6	14.16	13.20	−14.0		11.8	24.4			
July 29, '08	3212	10.7	14.62	13.66	−11.5		15.3	28.2			
11h38m8	3213	−16.8	14.82	13.86	−12.0		15.2	28.3			
2889	3214	−22.8	14.79	13.83	11.9	24.8					
July 31, '08	3215	−21.0	12.75	11.79	17.6	28.6					
10h57m1	3216	17.0	14.57	13.61	18.7	31.4					

TABLE I—Continued

Plate Number and Date	Number	Interval	Diurnal Motion		Declination Days of Observation						
			Normal	Observed	1	2	3	4	5	6	7
2889	3217	20 6	14°04	13°68	11°8	24°0					
		13 3	14 89	13 93	- 6 2	6 8					
		15 1	14 14	13 18	- 8 0	4 5					
		13 2	13 21	12 25	- 5 8	7 1		30°8			
			14 25	13 29	- 5 0	6 4					
		17 6	14 14	13 18	-23 1	-10 8					
2904 Aug. 1, '08											
2923	3223	- 9 5	14 64	13 68	- 3 9	12 1	22 9				
Aug. 3, '08	3224	12 3	13 85	12 89	-14 2	1.2	11.0				
		14 0	13 99	13 03	-28 2	-12.8	- 2.7				
	3226	16 8	14 24	13 28	-28 9	-12.7	- 3.0				
		11 5	14 74	13 78	-32 7	-16.1	- 5.8				
	3228	6 4	14 34	13 38	-39 3	-23 0	-13.2				
	3229	7 4	14 09	13 13	-41.3	-25.2	-15.7				
	3230	8 4	14 88	13 92	-43.8	-27 2					
		-16 7	14 34	13 38	-43.3	-27.0	-17.2				
2912	3232	- 8 7	14 07	13 11	10.9	20.9					
Aug. 4, '08	3233	-17 4	14 34	13 38	11.1	21.3					
	3234	-15 0	14 21	13 25	8.9	19.0					
	3235	-18 9	13 16	13 20	7.5	16 8					
	3236	-29 0	13 68	12 72	12 6	22 3					
	3237	-21 5	13 81	12 85	5.7	15.5					
	3238	-19 8	14 47	13 51	3 4	13.7					
	3239	-21 5	13 29	12 33	- 0 2	9.2					
	3240	-23 1	14 47	13 51	- 3.5	6.8					
	3241	-24 8	13 16	12 20	- 6 8	2 5					
	3242	-27 4	13 55	12 59	- 8 6	1.0					
	3243	- 3 1	12 89	11 93	-13.1	- 4.0					
	3244	-23 5	13 81	12 85	- 9.5	0.3					
	3245	-20 1	13 29	12 33	- 9.4	0.0					
	3246	-19 8	13 03	12 07	- 5.7	3.5					
	3247	-15 0	14 21	13 25	-14.4	- 4.3					
	3248	-13 5	13 42	12 46	- 0.1	9.4					
	3249	-10 2	13 94	12 98	3.2	13.1					
	3250	-14 1	13 68	12 72	5.3	15.0					
	3251	-16 6	13 16	12 20	-25 0	-15.7					
	3252	-15 2	13 16	12 20	-31.5	-22.2					
	3253	- 9 3	14 34	13 38	-37 3	-27.1					
	3254	1 8	14 47	13 51	2.9	13.2					
	3255	5 6	13 94	12 98	1.2	11.1					
	3256	14 7	13 94	12 98	- 0 9	9.0					
	3257	17 9	14 34	13 38	- 1.8	8.4					
	3258	21 6	14 55	13 59	-11 6	- 2 0					
	3259	19 8	14 07	13 11	-17.0	- 7.0					
		11 8	14 07	13 11	-20 0	-10 0					
		8	14 21	13 25	-17 9	- 7.8					
		7	13 68	12 72	-29 4	-19.7					
	3263	10 4	13 81	12 85	-27 0	-17 2					
		12 4	14 07	13 11	-29 6	-19 6					
		17 5	13 81	12 85	-42 0	-32 2					
		20 3	14 07	13 11	-44 9	-34.9					
		17 5	14 34	12 85	31 8	41 6					
2915 Aug. 7, '08											
		9 2	14 89	13 89	11 5	26 7					
Aug. 13, '08			14 75	13 91	11 9	25 7					
	3271		14 89	13 56	8 4	23 2					
		- 3	13 55	12 56	6 0	20 2					

TABLE I—*Continued*

PLATE NUMBER AND DATE	NUMBER	LATITUDE	DIURNAL MOTION		LONGITUDES ON DATES OF OBSERVATION						
			Sidereal	Synodic	1	2	3	4	5	6	7
2946 (*cont.*)	3273	11°6	14°50	13°53	7°1	21 9					
	3274	13 6	13 95	12 98	2 2	16 4					
	3275	11 7	14 77	13 80	− 2.2	12 9					
	3276	10.4	14.04	13 07	6 1	8.2					
	3277	12 0	14 04	13.07	− 7.1	7.2					
	3278	10.8	14.68	13 71	−10.7	4.3					
	3279	14 9	14 22	13.25	−14.6	− 0.1					
	3280	15 8	14.50	13 53	−21.0	− 6.2					
	3281	14.3	13.68	12.71	−22.6	− 8.7					
	3282	10 0	14.41	13 44	−24.8	−10.1					
	3283	−16.6	14 86	13.89	5.3	20 5					
	3284	−19.5	15.05	14.08	4.6	20.0					
	3285	−19.7	13.95	12.98	−10.1	4.1					
	3286	− 6.7	14.50	13 53	− 2.7	12.1					
	3287	− 3.3	13.95	12.98	− 5.0	9.2					
	3288	− 3.1	13.77	12.80	− 9.8	4.2					
	3289	− 3 6	14.04	13.07	−13.6	0.7					
	3290	−19.7	14 22	13 25	−23 7	9 2					
	3291	−16.9	13.77	12 80	25 8	−11.8					
	3292	−20.7	13 86	12 89	−27.3	−13 2					
	3293	−20.9	14.41	13.44	−31.2	−16 5					
	3294	−18.5	13.49	12.52	−29 7	−16.0					
	3295	−21.0	14.50	13 53	−44.8	−30.0					
2955 Aug. 14, '08 11^h48^m2											
2968 Aug. 21, '08 10^h39^m5	3296	−13.1	14 55	13.58	32.5	45.3					
	3297	−17.7	14.23	13.26	30 9	43.4					
	3298	−10 2	14.23	13.26	27.6	40.1					
	3299	−20.2	14.76	13 79	18 9	31.9					
	3300	−18.2	14.87	13.90	16 0	29.1					
	3301	4.9	14.76	13.79	23.0	36 0					
	3302	3.6	14.76	13.79	21.4	34.4					
	3303	5.4	14.23	13.26	20.6	33.1					
	3304	5.1	15.29	14.32	18.2	31.7					
	3305	7.8	15.08	14.11	17.8	31.1					
	3306	15.1	14.02	13.05	22 6	34 9					
	3307	21.9	14.76	13.79	20.8	33.8					
	3308	17.0	14 55	13 58	18 0	30.8					
	3309	15.9	13 81	12.84	12 9	25.0					
	3310	17.9	13.91	12.94	10 3	22.5					
	3311	18.2	14 65	13.68	14.4	27.3					
	3312	16.2	14 55	13 58	17.1	29 9					
	3313	0.2	14 55	13 58	7.8	20 6					
	3314	− 2.8	14.02	13.05	4.9	17.2					
	3315	− 3 2	13.70	12.73	0.9	12.9					
	3316	−17.6	14.44	13.47	2.2	14.9					
	3317	3.3	13.91	12.94	− 4 0	8.2					
	3318	− 2.5	15.18	14.21	−12.0	1.4					
	3319	− 5.8	15.08	14.11	−13.3	0.0					
	3320	− 7.4	14.55	13 58	−11.0	1.8					
	3321	−10.0	14.76	13.79	−12.0	1.0					
	3322	− 8.1	15.40	14 43	−19.3	− 5.7					
	3323	−17.9	14.34	13.37	−22.9	−10 3					
	3324	−18.0	14.34	13.37	−31.9	−19 3					
	3325	−20.7	14.02	13.05	−40.1	−27.8					
	3326	−18.3	14.12	13.15	−38 9	−26.5					
	3327	−12.3	14.55	13.58	−36.0	−23.2					
	3328	7.3	13.27	12.30	−18.2	− 6.6					
	3328′	4.5	15.18	14.21	−13.1	0 3					
	3329	− 1.1	15.71	14.74	16.0	29.9					
	3330	− 3.5	15.50	14.53	23.0	36.7					
2971 Aug. 22, '08 9^h17^m0											

TABLE I (Continued)

Group, Number, Date	Name	Epoch	Declination Motion		Longitudes on Dates of Observations						
			Seconds	Seconds	1	2	3	4	5	6	7
3357	...1	−12°4	14 94	13 97	47 6	33 1	44 3				
Aug. 27, '08	...2	-14 2	14 83	13 86	14 6	30 8	41.7				
	3333	-11 0	15 00	14 03	14 6	31.1	42.0				
	3334	-10 6	14 51	13 54	12 6	28.9	39.0				
	3335	-11.2	14.77	13 80	11 0	27 4					
	3336	-14.1	14 47	13 50	7.8	23.5	34.2				
	3337	-16 9	14.45	13 48	−13.4	2.0	12.2	26°8			
	3338	-18 6	14 50	13 53	−17 3	- 0.7	9 1	23.1			
	3339	-30.1	15 28	14.31	−19 3	- 2.3					
	3341	17 8	13 93	12 96	− 8 3	7.1					
	3342	10 4	14.18	13 21	−36 5	-20.8					
	3343	9 9	14 27	13 30	−38 0	-22.2					
	3344	10 4	14.84	13 87	−40 8	24 5	-13.7				
	...45	10 1	14.73	13 76	−43.0	-26 9	-16.1				
3346	3346	- 6 8	15 39	14 41	30 2	41.2					
Aug. 28, '08	3347	-18 5	14 87	13 89	29 9	40.5					
	3348	-19 8	14 94	13 96	− 1.3	9 6	23 7				
	3349	-23 9	14 85	13 87	− 2.5	8.0	22 3				
	3350	-22 1	14 20	13 22	− 6 4	3.2	17.2				
	3351	-16 6	14 61	13 63	20 6	31.0					
	3352	-18.7	14 12	13.14	− 5.7	4 2	17.9	30.3			
	3353	-16 1	14 34	13 36	−13 6	- 2.8	10.7				
	3354	9.5	14 22	13 24	−19 5	- 8.8	4.5	17 0			
	3355	- 6 0	15 29	14 31	20 0	30.9	45.6				
	3356	0 2	14 61	13 63	31 6	42 0					
	3357	-18 7	14 96	13 98	4.5	15.1	29.5				
	3358	-15 0	15 21	14 23	4.4	14 8	29.8				
	...59	-15 4	14 61	13 63	5.7	16.1					
	3360	-29 8	14.48	13 50	19.7	30 0					
	3361	7 4	14.95	13 97	−49.5	−38.7	-24.7	-11.0			
	...62	- 5.9	14.69	13.71	−48.2	−37.7	-23.1	-10.7			
3363	3363	−13 3	14 59	13 61	− 8.9	4.7	18.1				
Aug. 27, '08	3364	- 7.9	14 09	13.11	−45.1	−31.3	-19.1				
	3361′	−13 0	13 94	12 96	−44.7	−31.1	-19.0				
	3362′	5 3	14 74	13.76	1.3	14.9	29.0				
	3363′	−13 8	14 54	13 56	−10 8	3.0	16.1				
	3364′	2 3	15.80	14 82	−47.3	−32.1					
3339	3343′	−17 1	14 23	13 25	−38 5	−25.8					
Aug. 28, '08	3344′	−23 0	14.13	13 15	-28 5	−15.9					
	3345′	−19 3	14 03	13.05	-38.4	−25.9					
	3346′	−10 3	13 61	12 63	-34.0	−21.9					
	3347′	−15 1	13 92	12 94	-31 3	−18.9					
	3348′	−13 4	13 59	12 52	-32.1	−20 1					
	3349′	−14 0	14 65	13 67	-28 3	−15.2					
	3350′	−10 1	13 71	12 73	-26 0	−13.8					
	3351′	13 7	13 92	12 94	-45.9	−33.5					
	3352′	0 9	13 92	12 94	-41.6	−29 2					
	3353′	4 0	13 61	12 63	-38 1	−26.0					
	3354′	9 1	14 65	13 67	-26 1	−13.2					
	3355′	−16 4	14 13	13 15	25 6	38 2					
	3356′	16 5	13 44	13 46	− 1 8	11.1					
	3357′	16 5	13 40	12 42	− 5 7	17 6					
	3358′	13 8	14 82	12 84	1 4	13 7					
	3359′	10 0	14 65	13 67	0 3	13 4					
	3360′	9 3	14 34	13 36	2 2	15 0					
3340	3369	13 6	14 [illegible]	13 41	-24 1		4 0	15 2	30 0	43°0	
Aug. 28, '08	3370	7 0	14 [illegible]	13 31	− 9 1		9 7	3.7	18 0	30 8	44°2
	3368	−11 4	14 44	13 46	-32 2		5 2	8 3	22 1		
3341	3365	− 5 8	14 07	13 09	18 0	31 [illegible]	44 5				
Aug. 31, '08	3366	10 [illegible]	14 32	13 34	10 9	27 [illegible]	40 9				
	3367	14 [illegible]	15 41	14 81	− 6 5	[illegible]	37 7				
	3368	12 7	13 [illegible]	[illegible]	0 9	19 [illegible]	[illegible]				
	3371	4 [illegible]	13 [illegible]	[illegible]	2 [illegible]	14 9	25 5				
	3372	4 [illegible]	14 [illegible]	[illegible]	− 0 [illegible]	16 [illegible]	27 4				
	3370	4 6	14 [illegible]	13 30	1 6	15 8					

TABLE I *Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes of Displaced Groups						
			Sidereal	Synodic	1	2	3	4	5	6	7
3013 (*cont.*)	3374	3°.1	15°.08	14°.10	5°.9	19°.9					
	3375	0.1	14.76	13.78	9.0	23.2	36°.9				
	3376	− 4.0	14.55	13.57	10.9	24.7	38.3				
	3377	− 6.9	14.72	13.74	7.9	21.5	35.7				
	3378	−10.0	14.17	13.19	8.1	21.2	34.8				
	3379	−18.5	15.21	14.23	7.8	21.7	36.6				
	3380	−17.0	13.97	12.99	7.1	20.0					
	3381	−14.8	14.47	13.49	3.1	16.8	30.7				
	3383	−11.1	14.67	13.69	− 3.1	10.5	24.9	37°.9			
	3384	−12.5	14.72	13.74	− 5.6	7.9	22.2				
	3385	−13.3	14.57	13.59	− 8.3	5.0	19.2				
	3386	−18.3	14.88	13.90	− 4.8	9.0					
	3387	−21.7	14.61	13.63	− 5.0	9.0	22.8	36.0			
	3388	−21.0	14.71	13.73	− 9.8	4.2	18.1	31.5			
	3389	−12.5	13.98	13.00	−21.3	− 8.7	5.1	17.5	31°.5		
	3390	−10.5	13.27	12.29	−31.8	−19.6					
	3391	− 8.6	14.37	13.39	−37.6	−24.7	−10.5				
	3392	− 7.6	14.47	13.49	−40.9	−27.8	−13.6				
	3393	20.9	14.02	13.04	−12.0	1.2	14.5	27.5	41.0		
	3394	16.2	14.50	13.52	−14.6	− 0.9	12.7	26.1			
	3395	18.7	14.34	13.36	−17.1	− 4.0	9.8	23.0			
	3396	18.6	14.68	13.70	−22.2	− 8.6					
	3397	18.9	14.29	13.31	−29.3	−15.3	− 1.2	10.9	25.0	38.3	
	3398	14.6	14.56	13.58	−26.2	−13.0	1.0	14.7	28.8		
	3399	12.2	14.88	13.90	−33.0	−19.2					
	3400	8.9	14.76	13.78	−25.9	−12.5	2.0	15.2	30.1		
	3401	9.2	14.78	13.80	−22.9	− 9.5	4.8	18.5			
	3402	6.2	14.78	13.80	−24.1	−10.7	.. 3.5	16.9	31.4	45.3	
3025 Sept. 1, '08 9^h18^m4	3403	9.8	15.34	14.36	28.8	43.6					
	3404	9.1	14.32	13.34	8.9	22.9	35.7				
	3405	5.3	14.71	13.73	6.0	19.9	33.6				
	3406	1.8	14.72	13.74	6.3	20.9	33.9				
	3407	2.2	15.43	14.45	15.3	30.2					
	3408	−10.0	13.92	12.94	14.9	28.9	42.9				
	3409	−12.6	14.27	13.29	22.1	35.8					
	3410	−13.8	15.24	14.26	21.9	36.6					
	3411	−16.4	15.14	14.16	22.4	37.0					
	3412	−19.7	15.24	14.26	20.0	34.7					
	3413	−25.1	14.85	13.87	16.7	31.0					
	3414	−15.2	14.17	13.19	− 1.0	12.6					
	3415	16.7	14.38	13.40	1.9	15.0	29.0	42.8			
	3416	21.1	14.09	13.11	5.6	19.7	32.5	45.9			
	3417	16.9	15.24	14.26	− 4.8	9.9					
	3418	− 2.9	14.68	13.70	−26.0	−11.9	1.8	16.0			
	3419	− 8.9	14.56	13.58	−27.5	−13.5					
	3420	−10.8	14.69	13.71	−29.9	−15.8	− 2.2	11.9	25.7		
	3421	−11.5	15.05	14.07	−31.7	−17.2					
3033 Sept. 2, '08 10^h02^m8	3422	− 7.6	15.08	14.10	− 3.7	10.1					
	3423	−10.9	14.41	13.43	−18.9	− 5.0	8.6	21.8			
	3424	0.2	13.96	12.98	− 8.6	− 4.1					
	3425	18.1	14.16	13.18	−33.0	−20.1					
	3426	1.7	13.34	12.36	23.1	35.2					
	3427	−21.6	14.67	13.69	30.1	43.5					
	3428	−12.5	14.88	13.90	9.1	22.7					
	3429	−21.6	14.59	13.61	13.1	26.5	40.8				
	3430	−14.1	14.54	13.56	7.9	21.1	35.7				
	3431	10.2	14.06	13.08	19.9	32.7					
	3432	12.6	14.10	13.12	19.0	32.0	45.8				
	3433	− 6.0	14.37	13.39	−18.7	− 5.9	8.2	21.7			
	3434	18.4	14.44	13.46	− 6.2	6.4	20.9	34.3			
3039 Sept. 3, '08 9^h32^m2	3436	17.0	14.33	13.35	27.0	41.2					
	3437	23.5	14.33	13.35	20.0	34.2					
	3438	10.6	14.33	13.35	13.4	27.6					
	3439	15.1	13.76	12.78	5.0	18.7	31.0				
	3440	16.6	14.49	13.51	8.6	22.9	36.1				
	3441	10.5	14.33	13.35	10.6	23.9	37.8				
	3442	17.9	14.49	13.51	9.9	24.0	37.4				

TABLE I (Continued)

Point, Number and Date	Number	Residual	Period in Days: Sidereal	Synodic	Longitudes Used of Observations: 1	2	3	4	5	6	7
3044	3443	8 7	14°98	14°00	29°9	43°5					
Sept. 4, '08	3445	14 6	14 37	13 39	20 8	33 8					
	3446	− 4 1	14 16	13 18	22 0	34 8					
	3447	4 2	14 88	13 90	8 5	22 0					
	3448	− 0 5	[illegible]	12 97	8 9	21 5					
	3449	− [illegible]	14 37	13 39	9 9	[illegible]					
	3450	− 8 1	14 47	13 49	14 0	27 1					
	3451	9 0	[illegible]	13 28	12 5	[illegible]					
	3453	− 6 4	14 47	[illegible]	16 3	29 4					
	3455	15 4	14 67	[illegible]	26 3	39.4					
3048											
Sept. 5, '08											
[illegible]											
3058	3457	7 1	14 38	13 40	2 0	15 6	28°2				
[illegible]	3458	9 9	14 71	13 73	1 3	15 0	28 2	41°2			
10h48m2	[illegible]	8 8	14 53	13 55	− 0 8	12 9	25.7				
	[illegible]	8 2	14 61	13 63	− 4.1	8 3	21.8	35.4			
	3461	−13 3	14 78	13 80	3.1	17.0	30 1				
	3462	− 8 8	14 59	13 61	− 0 6	13 9	26 0				
	3463	−12 2	14 60	13 62	− 7 3	6.6	19.7	32.3			
	3464	−17 4	14 45	13 47	− 7 3	6 0					
	[illegible]	−16 4	14 17	13 19	− 9 9	3.7	15 9		..		
	[illegible]	−14 3	13 81	12 83	−11 4	1 1	13.7				
	3467	−20 9	14 35	13 37	− 8.9	[illegible]					
	3468	−20 3	14 12	13 14	−10 9	2 6	14.8				
	[illegible]	−11 7	14 85	13 87	−14 9	− 1.2					
	3470	[illegible]	14 86	13 88	−12 0	2 2	15 5	28.5	43°5		
	3471	[illegible]	14 58	13 60	− 8 9	5 0	18 0	30.9	45 1		
	3472	[illegible]	14 78	13 60	− 8.1	5.8	18 5				
	3473	[illegible]	14 47	13 49	−14 8	− 1.1	12 2	24 3			
	3474	6 9	14 90	[illegible]	−14.7	− 0.9	12 9	25 8	40 8		
	3475	18 2	14 73	13 75	−19 3	− 6.0	7.6				
	3476	[illegible]	14 84	13 86	−22 8	− 8.9	4.7	17.8	32.4		
	3477	[illegible]	[illegible]	[illegible]	−24.1	−10.6	2.4				
	3478	[illegible]	14 17	13 19	−25.4	−12 2	0.4				
	[illegible]	[illegible]	14 24	13 26	−27 0	−13 9					
	[illegible]	13 1	14 46	14 48	−29 3	−15 0					
	[illegible]	15 5	14 79	13 81	−33 0	−19.0	− 6.0				
	[illegible]	17 7	14 87	13 87	−38 1	−24.4					
[illegible]	3484	− 2 7	14 71	[illegible]	0 7	14 0					
[illegible]	3485	− [illegible]	14 33	13 35	1 0	15 9	28 6				
[illegible]	[illegible]	[illegible]	14 49	13 51	2 8	15 9	28.7				
	3487	− 5 0	14 74	[illegible]	3 1	16 3	29 9	41 2			
	[illegible]	−14 1	14 38	13 40	−35 0	−22 2	− 9 3				
	3489	−10 1	14 91	13 93	− 0 8	13 0	26 2	41.0			
	[illegible]	19 2	14 82	12 84	−12 4	0 0	12 2	26 1			
	3491	19 0	14 41	13 43	− 7 0	6 0					
[illegible]	[illegible]	3 2	[illegible]	13 60	24 1	37 0					
[illegible]	[illegible]	[illegible]	[illegible]	13 39	17 9	30 6					
[illegible]	[illegible]	[illegible]	[illegible]	13 70	17 5	[illegible]					
	[illegible]	[illegible]	[illegible]	13 28	13 0	25 6					
	3496	[illegible]	[illegible]	13 49	15 5	28 3					
	[illegible]	[illegible]	[illegible]	12 33	31 3	43 0					
	[illegible]	[illegible]	[illegible]	13 70	− 0 7	12 3					
	[illegible]	10 1	14 47	[illegible]	− 1 2	11 6	[illegible]				
	[illegible]	[illegible]	[illegible]	13 24	− 2 9	[illegible]	24 0				
	[illegible]	6 7	14 47	13 49	11 0	23 8					
	[illegible]	−17 6	[illegible]	[illegible]	−14 8	− 2 0	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]	−16 8	[illegible]					
	[illegible]	[illegible]	[illegible]	12 96	−26 6	−14 3					
	[illegible]	14 5	[illegible]	[illegible]	28 5	[illegible]	− 2 0				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	35 1				
	[illegible]	16 [illegible]	[illegible]	[illegible]	− 1 6	10 9	[illegible]				

TABLE I *Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
3083	3509	− 2°5	14°75	13°77	33°3	48°2					
Sept. 11, '08	3510	12.9	14 66	13 68	12.6	27.4					
8h31m1	3511	−18.0	14.38	13.40	0 0	14.5					
	3512	−18.3	15.40	14.42	−44.4	−28.8					
	3513	−11.1	13.46	12.48	−45.5	−32.0					
3090											
Sept. 12, '08											
10h29m4											
3094	3514	−10.7	14 70	13 72	1 1	15.2	29°0				
Sept. 15, '08	3515	−15.6	14.67	13.69	− 1.2	13.3	26.8	39°8			
9h41m2	3516	−18.9	14.79	13.81	− 1.8	12.8					
	3517	−21.0	14.22	13.24	− 1.5	12.5					
	3518	−19.3	14.21	13.23	− 3.2	10.8	23.7				
	3519	−21.1	14.01	13.03	− 3.4	10.3	23.1				
	3520	−20.4	14.44	13.46	− 6.0	8.2	21.3	34.4			
	3521	−22.3	14.08	13 10	− 7.3	7.4	19.8	32.1			
	3522	−20.1	13.94	12.96	−10.7	3.0					
	3523	−25.7	14.22	13.24	−13.0	1.0					
	3524	−13.8	14.98	14 00	− 9 5	5.3					
	3525	−10.9	15.35	14.37	12 5	27.7					
	3526	−11.2	14.65	13 67	9.9	24.3	37.7				
	3527	−15.4	14.69	13.71	−10.3	4.1	17.1	31.2	44°8		
	3528	− 0.2	14.76	13.78	−12.3	2.5	15.7				
	3529	− 0 7	14.48	13.50	−16 9	− 2.5	10 8	23.5	37.7		
	3530	4.6	14.51	13 53	−16.5	− 2.6	10.9	24.0			
	3531	4.6	14.21	13.23	− 2.2	11.8	24.7				
	3532	− 9.2	14.34	13.36	−40.1	−25.7	−12.2	− 0.2			
	3533	−23.2	14.79	13.81	−11.7	2.9					
	3534	21.3	13.84	12.86	− 5.9	7.7					
3100	3535	− 9.9	15.35	14.37	17.5	31.4	45.4				
Sept. 16, '08	3536	− 7.8	14.62	13.64	19.5	32.8					
11h04m	3537	− 7.6	14.51	13.53	21.0	34.2					
	3538	−14.6	14.82	13.84	17.4	30.8					
	3539	−12.9	14.26	13.28	4.4	17.2	30.2				
	3540	− 8.0	14.50	13.52	0 9	14.0	27.2	41.1			
	3541	0.0	14.82	13.84	− 3.9	9.6					
	3542	3.8	15.14	14.16	− 8.9	6.0	18.6				
	3543	−18.1	14.21	13.23	12.1	25.0					
	3544	−20.3	13 39	12 41	14.7	27.7	38.8				
	3545	−21.9	14 93	13 95	19.6	32.9	46.7				
	3546	− 3.1	14.92	13.94	7.3	6.3					
	3547	− 7.1	14.32	13.34	−26.5	−13.8	− 0.6				
	3548	−20.5	14.17	13.19	−33.0	−20.1	− 7.4	6.0		32°5	
	3549	−20.3	14.00	13.02	−40.7	−28.0					
	3550	15.3	14.34	13.36	− 6.0	•7.1	19.9	33.8			
	3551	− 3.4	13.80	12.82	3.2	15.7					
	3552	− 0 6	14.62	13.64	− 0.3	13.0					
3104	3553′	−11.7	14.74	13.76	28.0	41.3					
Sept. 17, '08	3554	− 5.5	14.94	13.96	18.0	31.5					
10h28m6	3555	−20.2	14.12	13.14	15 6	28.3					
	3556	− 5.3	14.47	13.49	−37.9	−25.0	−11.1		15.8		
	3557	4.8	14.15	13.17	−29.3	−16.7	− 3.8		23.2		
	3558	− 4.5	14.84	13 86	−33.0	−19.6					
	3553	−17.0	14.32	13.34	16.5	29.4					
3109	3559	1.1	14.60	13.62	26 9	41.0					
Sept. 18, '08	3560	− 2.1	14.12	13.14	29.8	43.4					
9h40m6	3561	− 9.7	14.12	13.14	19.3	32.9					
	3562	20.8	13.63	12.65	30.9	44.0					
	3563	7.9	14.50	13.52	−17.7	− 3.7					
	3564	5.8	14.43	13.45	−22.0	− 7.9		18.6			
	3565	4 1	14.50	13.52	−25.0	−11.4		15.7			
	3566	5 8	14.41	13.43	−27.4	−13.5					
	3567	10.4	14.12	13.14	−29.6	−16.0					

TABLE I—*Continued*

Plate No. and Date	No.	Comet—Mean	Observed—Mean		Residuals on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
3109 *(cont.)*	[illegible]	12°.4	[illegible]	12°.85	[illegible]	−12.5					
	[illegible]	8.3	14 12	13 14	−19.7	− 6.1					
	[illegible]	− 7.6	14 [illegible]	13 11	−21.1	− 7.2		18°.5			
	3571	−19.1	14 [illegible]	13 [illegible]	−15.3	− 1.5					
	[illegible]	− 8.0	14 79	13 81	−32.5	−18.2					
	3573	−11.8	14 79	13 81	− 7.7	6.6					
3113	3574	− 8.9	15 53	14 54	−18.5		10°.3				
[illegible]	3575	−14.8	14 57	13 58	−12.2		14.7				
10h31m.5	[illegible]	−14.1	14 [illegible]	13 63	−37.1		−10.1				
	3577	−17.2	15 86	12 87	−41.3		−15.8				
	3578	−13.8	14 11	13.12	8.9		18.0				
3117 Sept. 21, '08 [illegible]											
3121	3579	18.5	[illegible]	12.39	16.0	28.5					
Sept. 25, '08	3580	16.5	[illegible]	13 29	13.9	27.1					
[illegible]	3581	13.2	[illegible]	12.99	14.5	27.4					
	[illegible]	13.6	14 18	13 19	11.9	25.0					
	[illegible]	[illegible]	[illegible]	13 90	9.2	23.0					
	[illegible]	[illegible]	[illegible]	13 09	− 0.2	12.8					
	3585	10.0	15 29	14 30	− 1.1	13.1					
	[illegible]	2.5	14 89	13 90	− 3.9	9.9					
	[illegible]	10.6	14 08	13.09	− 5.5	7.5					
	[illegible]	12.1	13 88	12 89	− 6.1	6.7					
	3589	−19.4	14 38	13 39	−17.9	− 4.6					
	[illegible]	[illegible]	14 48	13 49	−17.6	− 4.2					
	[illegible]	[illegible]	[illegible]	12.49	−24.5	−12.1					
	[illegible]	[illegible]	[illegible]	14 00	−10.7	3.2					
	[illegible]	−18.5	14 08	13 09	−27.0	−14.0					
	[illegible]	3.5	14.48	13 49	−10.1	3.3					
	3595	[illegible]	[illegible]	14 10	− 9.5	4.5					
	[illegible]	[illegible]	[illegible]	12 89	−18.2	− 5.4					
	[illegible]	[illegible]	[illegible]	12 89	−14.0	− 1.2					
	[illegible]	[illegible]	[illegible]	12 89	−13.8	− 1.0					
	[illegible]	[illegible]	[illegible]	[illegible]	−20.1	− 7.0					
	[illegible]	[illegible]	[illegible]	[illegible]	−21.0	− 7.6					
	3601	[illegible]	[illegible]	[illegible]	−24.5	−11.0					
	[illegible]	[illegible]	[illegible]	12 99	−23.1	−10.2					
	[illegible]	[illegible]	[illegible]	13 69	−26.2	−12.6					
	[illegible]	[illegible]	[illegible]	12 99	−32.2	−19.3					
	[illegible]	[illegible]	[illegible]	[illegible]	−31.0	−17.9					
	[illegible]	[illegible]	[illegible]	[illegible]	−31.0	−17.0					
	[illegible]	[illegible]	[illegible]	13 29	−30.0	−16.8					
	[illegible]	[illegible]	[illegible]	[illegible]	−20.7	− 7.6					
	[illegible]	[illegible]	[illegible]	[illegible]	−29.8	−16.3					
	3610	[illegible]	14 38	13 39	8.3	21.6					
3124 Sept. 30, '08 [illegible]											
[illegible]	3611	[illegible]	[illegible]	13 36	34.2	47.8					
Sept. 29, '08	[illegible]	[illegible]	[illegible]	[illegible]	29.8	42.9					
[illegible]	[illegible]	[illegible]	[illegible]	13 07	33.3	46.6					
	[illegible]	[illegible]	[illegible]	13 36	32.1	45.7					
	[illegible]	[illegible]	[illegible]	13 07	[illegible]	39.8					
	[illegible]	[illegible]	[illegible]	13 76	23.9	41.2					
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	34.6					
	[illegible]	[illegible]	[illegible]	13 26	21.9	34.4					
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	37.3					
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	36.6					
	[illegible]	[illegible]	[illegible]	[illegible]	31.7	44.[illegible]					
	[illegible]	[illegible]	[illegible]	[illegible]	22.2	36.0					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
3128 *(cont.)*	3624	9°.5	13°.57	12°.58	9°.4	22°.2					
	3625	−17.3	14.45	13 46	26 3	40 0					
	3626	−16.3	14 16	13.17	24.8	38.2					
	3627	−21.6	15.04	14.05	15.1	29.4					
	3628	−24.7	13.27	12.28	5 5	18.0					
	3629	− 7.8	14.16	13.17	−12.1	1.3					
	3630	− 8.6	14.35	13.36	−10 6	3.0					
	3631	−14.8	15.33	14.34	−17.1	− 2.5					
	3632	6.8	14.71	13.72	−10 0	3.2		31°.1			
	3633	8.2	14.53	13.54	−12.2	1.1		28.2	42°.1		
	3634	18.4	14.54	13.55	− 1.8	11.9		38.9			
	3635	11.2	13.66	12.67	9 8	22.7					
	3636	23.3	13.76	12.77	7.0	20.0					
3132	3639	−13.8	14.77	13.78	− 3.0		24°.4				
Sept. 30, '08	3640	−16.4	14.88	13.89	−25.0		1.9	16.9			
9h37m	3641	−14.7	14.71	13.72	−40 0		−11.4	1.2		28°.8	
	3643	−10.8	14.29	13.30	−35.8		− 9.2	4.5		30.6	
3139	3646	2.4	14.96	13.97	29.3	43.5					
Oct. 2, '08	3648	− 9.9	14.66	13.67	21.6	35 5					
9h19m4	3649	−22.2	13.87	12.88	17.0	30.1					
	3652	−13.0	14.46	13.47	−17.0	− 3.3					
	3654	−14.4	13.98	12.99	−20.6	− 7.3		18.5			
	3655	−13.6	14.35	13.36	−23.3	− 9.2		17.0			
	3657	− 7.9	13.97	12.98	28.7	41.9					
	3658	−16.8	14.96	13.97	21.0	35.2					
	3659	−14.4	14 66	13.67	− 2.6	11.3					
	3660	−14.6	13.78	12.79	− 5.7	7.3					
	3661	−17.5	14.46	13.47	−23.8	−10.1					
	3662	6.5	13.09	12.10	−38.6	−26.3					
	3663	− 6.7	14.38	13.39	−40.5	−27.1		− 0.9		27.5	40°.2
3147											
Oct. 3, '08											
9h43m6											
3151	3664	7.4	14.77	13.78	− 0.7		28.0	40.9			
Oct. 5, '08	3665	− 4.3	14.58	13.59	− 6.1		22.3	34.9			
9h31m6	3666	− 2 5	14.45	13.46	− 8.9		18.9	31.8			
	3667	9.0	14.60	13 61	−23.4		4.9	17.2	31.7	44 4	
	3668	7.4	14.36	13.37	−21.3		6.2	18.2	32.4	45.5	
	3669	12.9	14.04	13 05	−21.9		5.3	17.1	30.3	43.5	
	3670	17 2	14 27	13.28	−22.2		5.2	17.8	31.3	44.0	
	3671	19 0	14.34	13.35	−24.0		3.9				
	3672	14.9	14.55	13.56	−25.9		2.2	15.1			
	3674	12.4	14.40	13 41	−17.7		10.1	23.0	36.0		
	3675	−12.1	14.77	13.78	−12.2		16.9	29.3			
	3676	−10.2	14.72	13.73	−19.2		9 8	22.1	36.0		
3158	3673	14.9	14.34	13.35	− 1.8	10.5	24.0				
Oct. 7, '08	3677	−10.8	14.03	13.04	22.2	34.3					
11h40m	3678	− 8.1	14.67	13.68	22.2	34.9					
	3679	− 4.8	15.00	14.01	17 8	30.8					
	3680	− 8.4	14.96	13.97	12.4	25.6	39.3				
	3681	− 6 2	14.29	13 30	11.7	23.7	37.3				
	3682	− 6.1	14.33	13.34	8.0	20.8	33.7				
	3683	− 8.9	14.39	13.40	7.0	19.7	32.8				
	3684	−12.7	14.78	13.79	9.0	21.8					
	3685	− 0.5	14.54	13.55	0.5	13.4	26.6				
	3686	4 5	14.03	13.04	2.9	15.0	28.0				
	3687	3.8	14.35	13.36	− 2.6	10.0	23.3	36.3			
	3688	−19.4	13.86	12.87	−12.5	− 1.4	11.2	25.1			
	3689	−13.3	14.35	13.36	−18.5	− 6.1					
	3690	−10 9	14.35	13.36	−19 8	− 7.4					
	3691	−10.4	14.13	13.14	−22.5	−10.0	2.8				
	3692	− 9 8	15.02	14.03	−27.1	−14.3	− 0.1				
	3693	−11.6	14.58	13.59	−28.2	−15.2	− 2.0	11.5			

TABLE I (Continued)

Plate Number and Date	Number	Correction	Period in Minutes		Logarithm of Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
3158 (cont.)	3694	−14.8	14°44	13°45	−28°7	−16°1	− 2°8				
	3695	−14 5	15 00	14 01	−31 0	−18 0					
	3696	17 2	14 03	13 04	− 6 0	6 1					
	3697	17 3	14 28	13 29	− 8 0	4 2	17 3	30°5			
	3698	22 0	14 14	13 14	− 3.3	8 7	22 0				
	3699	− 4 7	15 00	14 01	26 3	39 3					
3163 Oct. 8, '08 9h 30m	3700	−12 8	14 93	13 94	−33 4	−19.5					
	3701	− 7.1	16 03	15 04	27 9	42 9					
	3702	−14.7	14 73	13 74	19 2	32 9					
	3703	2 8	14 12	13 13	30.7	43 8					
	3704	− 2.7	14 43	13 44	23 9	37.3					
	3705	− 7.4	14.70	13 71	16 0	29 4	43 2				
	3706	−14 6	14 44	13.45	− 8 9	3.3	17.3		44 2		
	3708	− 7.2	14 55	13 56	−44 0	−30 5	−17.1				
	3709	− 8.5	14 75	13.76	−38 1	−24 5	−10 8				
	3711	19 3	14.12	13.13	22 0	35.1					
	3712	18 4	14 63	13.64	25.6	39.2					
3166 Oct. 9, '08 0h 32m	3710	14 6	14 62	13 63	−31 0	−17 8		9 2	23 0	38°3	
	3713	14 4	14.43	13 44	6 4	20 2		46.5			
	3714	−11.1	14 48	13 49	− 5 0	8.3					
	3715	− 8.9	14 18	13.19	− 4.1	9.1		35.2			
	3716	−15.5	14 18	13.19	−35 3	−22.2		3.9	17.4		
	3717	2 4	14.13	13 14	48 1	−34.6		− 9.2	4 7	18 8	
	3718	1 5	14 28	13 29	−44 3	−31.2					
	3719	21 0	14 07	13 08	13 0	25.9					
3170 Oct. 10, '08 9h 32m	3720	−13 2	14 21	13.22	−26.2		0 1	13.8	26.9	40.9	
3173 Oct. 12, '08 9h 18m	3721	−17.8	13 82	12.83	1 1	12.0	25.8	38 0			
	3722	−19 6	14.70	13.71	− 4.6	9 3					
	3723	−18 2	14 20	13 21	− 9.2	5 3					
	3724	−14.2	15.10	14 11	4.0	18.3					
	3725	−14 1	14.70	13 71	6 2	20.1					
	3726	−11.3	15 10	14.11	8.7	23.0					
	3727	2.1	14 76	13 77	− 4.1	9.6	24 8				
	3728	0 9	14.39	13 40	− 8.7	5 0	19 0	32.3			
	3729	8 0	15 28	14 29	− 9.2	5.2	20 8				
	3730	8 3	14 67	13 68	−12 0	1.3	17.1	29 3			
	3731	11.1	15 08	14 09	−10 1	4.0	19 8	32.6			
	3732	− 8 6	14 90	13 91	15 3	29.3	44 5				
	3733	−21 4	14 01	13 02	−19.5	− 6.3					
	3734	−20 6	14 29	13 30	−17 5	− 3.8	10 9	23 6	35 6		
	3735	8 6	14 71	13 72	−19 3	− 4.0	10 2	22 7			
	3736	11 2	14 11	13.12	27.7	41 0					
3177 Oct. 13, '08 9h 29m	3737	5 1	14 43	13 44	− 2.1	12.6	25 1	38 2			
	3738	11 2	14 18	13 19	− 3 1	11 9	24 2	36 4			
	3738'	0 4	14 31	13 32	3 0	17.3	29 8	42 9			
	3739	−26 9	14 16	13 17	2 0	16 3					
	3740	1 7	14 44	13 45	−10 8	3 8					
	3741	−12 1	14 53	13 54	−44 5	−29 8					
	3742	7 5	14 48	13 49	−35 4	−20 7	− 8 0	5 0			
	3743	8 5	14 [illegible]	13 54	−39 2	−24 5					
	3744	7 1	14 93	13 94	−41 7	−26 3	−13 1	0 0			
	3745	4 4	14 99	14 00	−30 2	−15 0					
	[illegible]	5 2	14 81	13 82	−24 0	− 9 0					
3182 Oct. 14, '08 11h 11m	3748	−27 8	13 79	12 80	14 4	26 5					
	3749	−21 1	14 53	13 54	25 0	37 8					
	3751	−19 7	13 90	12 91	15 7	27 9					
3188 Oct. 15, '08 10h 32m	3752	10 8	14 [illegible]	[illegible] 91	−12 1	0 9					
	3753	4 4	15 01	14 02	[illegible] 0	45 5					
	3745	−24 2	14 18	13 19	23 3	36 0					
	[illegible]	10 1	13 77	12 78	14 9	37 2					

TABLE I—*Continued*

Plate Number and Date	Number	Latitude	Diurnal Motion		Longitudes on Days of Observation						
			Sidereal	Synodic	1	2	3	4	5	6	7
3189 Oct. 16, '08 9^h28^m7											
3195 Nov. 2, '08 11^h55^m6	3760	− 7°7	14°18	13°18	14°9		40°8				
	3761	− 7.6	14.84	13.84	11.2		38.4				
	3762	− 7.7	14.64	13.64	8.1		34.9				
	3763	− 8 0	14.08	13 08	− 5.4		20.3				
	3764	− 3.9	14.58	13.58	−23.0		3 7				
	3765	17.6	14.23	13.23	− 2.1		23.9				
	3766	15.6	14.29	13.29	− 6.0		19 8		46°0		
	3767	− 5.8	14.42	13.42	−16.7		9.9		35.8		
	3768	−11.5	14.69	13 69	0 0		26.9				
	3769	−13 0	15.19	14.19	5.9		33.8				
	3770	15.3	14.33	13.33	0.5		26.7				
	3771	13.8	14.38	13.38	2.7		29 0				
	3772	− 6.9	14.99	13.99	− 0.8		26.7				
	3773	−22 9	13.16	12.16	−11.3		12.6				
	3774	−19 6	14.08	13.08	−19.2		6.5				
3197 Nov. 4, '08 11^h05^m9	3775	14.3	14.72	13.72	15 5		42 2				
	3776	12.6	14.41	13.41	14.1		40.2				
	3778	− 9.6	14.87	13.87	−37.7		−10.7				
3198 Nov. 6, '08 9^h48^m4											
3213 Nov. 19, '08 11^h50^m0	3779	0.9	14.65	13.64	22.9	36°5					
	3780	3.2	14.75	13.74	18.4	32.1					
	3781	6.2	14.45	13.44	18.9	32 3					
	3782	6.2	15.26	14.25	24.7	38.9					
	3783	− 5.2	15.46	14.45	33.3	47.7					
	3784	3.8	14.45	13.44	15.7	29.1					
	3785	6 0	14.65	13.64	14.6	28.2					
	3786	7 2	14.75	13.74	9.5	23.2					
	3787	13.4	14·55	13 54	15 0	28 5					
	3788	13.9	14 55	13.54	12.7	26.3					
	3789	15.8	14.35	13.34	8.0	21.3					
	3790	14.8	14.25	13.24	5.9	19.1					
	3791	8 9	15.16	14.15	4.9	19.0					
	3792	4.9	14.45	13.44	− 4.2	9 2					
	3793	0.0	14.75	13.74	− 6.5	7.2					
	3794	− 9.0	14.75	13.74	− 5.7	8.0					
	3795	7.1	13.95	12 94	− 9.0	3.9					
	3796	13.2	14 35	13.34	−31.1	−17.8					
3215 Nov. 20, '08 11^h45^m3											
3220 Nov. 27, '08 11^h36^m5	3797	− 6.8	14 87	13.86	5.9	19.9					
	3798	− 2.3	14.38	13.37	6.0	19.5					
	3799	7 4	14.28	13.27	−11.7	1.7					
	3800	5.1	14.97	13.96	−14.1	0.0					
	3801	13.2	13.88	12.87	−30.0	−17.0					
	3802	16.3	13.68	12.67	−29.7	−16.9					
	3803	16.0	13.78	12.77	−31.2	−18.3					
	3804	13.9	13.98	12 97	−35.1	−22.0					
	3805	15.5	14.18	13.17	−36 0	−22.7					
	3806	14.9	13.88	12.87	−38 0	−25.0					
	3807	−10 6	13.78	12.77	−13.1	− 0.2					
	3808	− 8.9	14.67	13.66	−18.3	− 4.5					

TABLE I—Continued

Number	Latitude	Diurnal Motion: Sidereal	Synodic	Longitudes for Days of Observation: 1	2	3	4	5	6	7
3809	−16°.6	14°.57	13°.56	−10°.2	.. 5					
3850	−16 .1	14 .77	13 .76	− 8 .9	5 .0					
3811	−16 .5	15 .27	14 .26	− 5 .2	8 .7					

Nov. 28, 08
11h 50m G

ZONAL SUMMARIES

The sidereal motions of Table I are collected in Table II in zones five degrees wide. At the head of each zone are given the mean latitude of the points and the mean diurnal sidereal motion. In obtaining these means all determinations were assigned equal weight. Those points which were followed for intervals of several days perhaps give more accurate determinations than those followed for but a single day, but in all points there was some change in form and this is surely larger for points followed over considerable intervals. Therefore the assignment of equal weight is considered justifiable.

TABLE II

ZONAL SUMMARIES

Zone 0 to 5 | Mean Latitude = 2°.88
Mean Diurnal Motion = 14°.58

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
184	2	15 .57	1°.3	2161	2	15 .36	3°.8	2701	2	14 .38	1°.2
277	7	14 .55	4 .1	2168	2	15 .20	4 .8	2704	2	14 .43	4 .4
340	2	15 .15	3 .9	2169	2	15 .60	2 .7	2764	3	14 .68	4 .1
762	2	15 .19	4 .5	2213	2	14 .36	4 .9	2770	3	14 .01	1 .4
881	2	15 .53	0 .8	2220	2	14 .55	4 .7	2775	2	15 .23	1 .1
886	2	14 .60	1 .6	2251	2	14 .92	0 .1	2825	2	15 .09	3 .8
1039	3	14 .82	0 .6	2279	2	15 .39	4 .0	2849	2	14 .42	1 .2
1066	2	14 .82	2 .6	2288	5	14 .26	4 .7	2850	2	14 .73	1 .4
1078	3	14 .79	3 .7	2319	2	13 .99	1 .9	2851	2	15 .51	2 .1
1115	3	15 .20	3 .3	2329	2	14 .49	4 .6	2852	2	15 .01	3 .8
1160	2	15 .35	2 .8	2421	2	14 .90	1 .8	2854	3	14 .67	0 .8
1166	2	14 .54	1 .9	2435	4	14 .99	4 .7	2861	2	14 .71	4 .9
1168	3	15 .26	5 .0	2436	2	14 .36	4 .8	2862	3	13 .93	0 .4
1191	2	14 .30	3 .5	2451	4	14 .58	0 .8	2868	2	14 .71	3 .4
1266	3	14 .68	3 .0	2462	2	14 .36	3 .2	2876	3	14 .62	4 .3
1280	2	14 .39	3 .9	2466	2	15 .26	4 .1	2890	2	15 .71	1 .2
1281	3	14 .39	2 .1	2476	3	14 .75	2 .3	2893	2	14 .93	4 .3
1292	2	13 .71	1 .4	2480	2	13 .58	3 .1	2900	2	15 .85	4 .8
1293	2	14 .68	4 .4	2505	2	14 .77	1 .9	2909	3	14 .42	7 .0
1297	2	13 .19	4 .5	2534	2	14 .78	1 .8	2920	2	14 .98	0 .7
1305	2	14 .44	4 .6	2569	3	14 .67	3 .1	2926	2	15 .58	0 .1
1307	2	15 .25	3 .4	2612	2	14 .72	2 .1	2948	2	14 .18	2 .5
1308	2	14 .74	1 .0	2625	2	14 .36	0 .7	2949	2	14 .43	2 .3
1310	2	15 .31	4 .2	2640	2	14 .32	2 .4	2972	2	15 .04	1 .5
1331	2	14 .93	1 .9	2650	4	14 .66	1 .9	3005	2	14 .11	1 .3
1339	3	14 .91	1 .3	2657	4	14 .05	3 .4	3052	2	14 .65	3 .2
1341	2	14 .43	1 .6	2658	3	14 .17	1 .3	3068	3	14 .22	3 .8
1370	3	14 .55	3 .6	2668	4	15 .05	3 .5	3069	3	14 .54	3 .8
1371	2	13 .97	2 .6	2685	4	14 .73	0 .4	3087	2	14 .82	0 .9
1391	3	14 .86	3 .2	2691	5	14 .79	2 .6	3140	2	14 .61	1 .0
1402	3	14 .66	0 .3	2672	3	14 .38	3 .2	3141	2	14 .31	3 .7
1408	3	15 .26	4 .3	2677	4	14 .19	0 .7	3170	3	13 .78	1 .5
2131	3	13 .61	3 .0	2687	4	14 .02	4 .6	3174	2	13 .47	3 .5
2145	3	14 .47	3 .9	2688	3	14 .39	4 .0				

TABLE II—*Continued*

Zone 0° to −5° { Mean Latitude = −2°.65
Mean Diurnal Motion = 14°.53

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
97	4	14°.13	−3°.9	2812	2	14°.02	−2°.3	3318	2	15°.18	−2°.5
208	2	13.71	−5.0	2813	2	14.23	−4.2	3329	2	15.71	−1.1
320	2	13.76	−2.4	2824	2	14.90	−1.3	3330	2	15.50	−3.5
336	2	14.81	−4.5	2828	2	14.02	−4.0	3376	3	14.55	−4.0
573	2	14.33	−4.8	2833	2	15.28	−0.1	3418	4	14.68	−2.9
640	2	14.37	−2.8	2834	2	14.90	−1.5	3446	2	14.16	−4.1
869	2	14.88	−2.1	2840	2	14.63	−4.7	3448	2	13.95	−0.5
870	6	14.23	−1.1	2841	2	14.53	−0.2	3449	2	14.37	−2.3
988	2	13.55	−4.6	2842	2	15.05	−0.9	3471	5	14.58	−4.1
1179	2	13.99	−3.3	2869	3	14.13	−3.6	3472	3	14.58	−2.0
1467	2	15.29	−2.8	2924	2	14.59	1.9	3473	1	14.47	−2.9
1659	2	14.43	−4.8	2947	2	14.52	−0.4	3484	2	14.71	2.7
1938	2	14.62	−0.1	2951	2	14.35	−4.0	3485	3	14.33	−0.9
2074	3	14.53	−4.4	2970	2	15.03	−4.6	3487	1	14.74	−5.0
2232	2	15.10	−0.3	2971	3	15.12	−3.1	3509	2	14.75	−2.5
2279	2	15.03	−4.8	2992	2	15.39	−4.2	3528	3	14.76	−0.2
2444	2	14.96	−0.9	3001	2	14.41	−4.6	3529	6	14.48	−0.7
2450	2	14.06	−2.2	3002	4	14.91	−0.1	3541	2	14.82	0.0
2455	2	14.16	−2.0	3004	5	14.61	−4.1	3546	2	14.92	−3.1
2565	3	14.43	−5.0	3008	2	14.60	−1.6	3551	2	13.80	−3.4
2566	2	14.61	−1.5	3009	6	14.94	−3.8	3552	2	14.62	−0.6
2567	1	13.91	−4.7	3051	2	14.93	−2.6	3558	2	14.84	−4.5
2631	2	13.96	−3.2	3088	2	14.62	−4.6	3560	2	14.12	−2.1
2642	2	13.74	−3.2	3089	2	14.01	−4.4	3592	2	14.99	−0.3
2662	2	14.84	−0.2	3090	2	15.03	−2.3	3609	2	14.58	−0.9
2676	5	14.23	−3.3	3094	2	14.62	−0.2	3623	2	14.55	−1.0
2678	3	14.48	−3.3	3139	2	14.51	−0.9	3665	4	14.58	−4.3
2702	2	15.09	−5.0	3171	2	13.99	−0.6	3666	4	14.45	−2.5
2703	2	14.69	−2.9	3178	2	13.77	−2.0	3679	2	15.00	−4.8
2719	3	14.87	−3.5	3179	2	14.58	−4.9	3685	3	14.54	−0.5
2726	5	14.17	−3.4	3182	3	14.59	−4.2	3699	2	15.00	−4.7
2731	2	14.81	−0.6	3197	3	14.90	−3.7	3704	2	14.43	−2.7
2735	4	13.89	−2.1	3287	2	13.95	−3.3	3717	6	14.13	−2.4
2807	3	15.03	−1.9	3288	2	13.77	−3.1	3738′	4	14.31	−0.4
2808	3	14.52	−4.9	3289	2	14.04	−3.6	3764	3	14.58	−3.9
2810	2	15.06	−0.8	3314	2	14.02	−2.8	3793	2	14.75	0.0
2811	2	14.85	−0.5	3315	2	13.70	−3.2	3798	2	14.38	−2.3

TABLE II—*Continued*

Zones 7° to 16° Mean Latitude = 7°86
Mean Diurnal Motion = 14°51

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
144...	4	15°28	8°1	1536	4	14 64	9 9	2380..	2	16°02	9°7
27...	4	13 83	7 2	1537	4	14 64	9 7	2381	2	15 39	6 9
172	4	14 49	7 5	1587	4	15 26	5 0	2382	2	15 39	5.7
274...	4	14 35	6 8	1600	4	14 30	8 9	2386..	3	14 26	8 2
278...	4	14 34	8 1	1605	4	14 35	9 3	2387..	3	14.15	6 9
294...	4	14 19	7 2	1646	4	13 93	8 4	2389..	3	14.38	8 1
295...	4	14 30	8 7	1671	4	14 60	7.5	2399..	2	15 60	9 1
299...	4	14 62	9 1	1699	4	13 99	5 0	2400..	3	13.95	6 0
300...	4	14 45	8 2	1700	4	13 93	7.1	2402..	4	14.24	7.6
305...	4	15 00	7 1	1707	4	14 69	8 2	2405..	2	14 29	8 8
339...	4	14 25	8 8	1738	4	14.19	9.9	2406..	2	14.09	8 8
362...	4	14 29	9 5	1741	4	14 39	7.8	2414..	2	13 58	7.8
393...	4	14 09	8 9	1742	4	14 09	7 3	2415..	2	14.19	9 9
421...	4	14 63	6 2	1764	4	14.49	8.4	2417..	2	14.39	8 7
484...	4	14 85	9 1	1794	4	14 68	9 9	2418..	2	14 09	5 7
529 ..	4	14 55	9 7	1795	4	14 49	10 0	2447..	4	13 86	9 1
530...	4	14 87	6 9	1796	4	14 39	5 3	2448..	4	14 30	8 6
533	4	14 44	6 0	1800	4	14 00	5 4	2449..	4	15 06	5 6
533...	4	15 08	6 2	1802	4	14 54	9 9	2454..	4	14 67	8 3
534...	4	14 44	7 5	1804	4	14 44	7.9	2474	3	15 00	7 9
597...	4	15 64	9 1	1804	4	14 74	8 3	2476..	3	14.75	7.0
599...	4	14 29	9 8	1805	4	15 05	6 9	2478	3	15 58	7 9
626 .	4	14 74	8 3	1807	4	14 95	6 9	2479	3	14.75	7 9
627...	4	14 78	8 7	1810	4	14 84	6 6	2480..	3	15 54	9 5
628...	4	14 55	6 1	1812	4	15.15	6 0	2481..	3	14 51	7.1
660...	4	14 38	6 7	1813	4	14 95	9.4	2484..	3	15 06	9 0
666 ..	4	14 45	9 5	1819	4	14 34	9 1	2485	3	14.23	9 3
667...	4	14 29	7 0	1850	4	15.55	8.6	2478'	3	14 96	6 1
668...	4	14 46	8 5	1852	4	13 43	9 3	2504..	4	15.38	7.2
670 .	4	15 80	8 0	1903	4	14.93	8.1	2507..	4	14 98	8.1
671...	4	15 00	9 1	1905	4	14 08	9 8	2508..	4	14 16	5.5
689	4	14 88	9 0	1913	4	14 65	7.8	2516 .	4	14 98	10 0
690...	4	14 50	6 1	1915	4	14 27	8 7	2519..	4	14 24	9.8
710 ..	4	14 78	8 8	1929	4	14 82	5 1	2541..	3	14.17	5 5
711...	4	14 77	8 6	1944	4	15 02	6 1	2610..	3	15 13	5 2
712...	4	14 17	6 0	1953	4	15 12	8.7	2611..	3	14 31	5 2
740...	4	14 69	9 7	1954	4	14 82	5 3	2614..	3	14 62	6 5
809...	4	14 79	8 8	1961	4	14 52	8 5	2640..	7	14 50	7.8
813...	4	14 65	8 4	1964	4	14 72	8 3	2641	4	14 84	9 8
913...	4	14 13	9 0	2003	6	14 46	8 4	2643..	4	15 17	6 3
941...	4	15 23	8 0	2022	4	14 89	9 1	2651..	4	13 81	6.7
1004...	4	15 43	6 7	2023	4	14 05	9 0	2654..	4	14 67	8.4
1020...	4	14 48	8 9	2024	4	14 16	8 1	2655..	4	14 55	9 9
1030...	4	14 52	10 0	2029	4	13 75	7.7	2659..	4	14 42	5 7
1031...	4	14 32	7 6	2030	6	14 24	9 3	2661	4	14 55	8 6
1038...	4	14 52	8 7	2057	4	14 65	6 3	2666	4	15 40	7 9
1084...	4	14 58	8 3	2071	4	14 93	8 9	2669..	3	14 90	5 8
1101...	4	14 87	8 3	2116	4	14 35	5 3	2670 .	3	14 72	5 8
1148...	4	14 77	9 3	2117	4	14 79	7.6	2674..	4	14 58	6 7
1318...	4	14 56	7 5	2119	4	14 29	8 5	2685	4	13 95	9 2
1319...	4	13 97	7 5	2120	4	14 76	5 5	2686 .	3	14 33	8 0
1320...	4	13 69	9 5	2193	4	14 38	8 2	2696..	4	13 98	9 6
1326 ..	4	15 06	8 2	2195	4	14 28	6 5	2705..	4	14 50	9 5
1327 ..	4	14 26	8 7	2196	4	14 28	5 2	2768..	4	14 62	7 4
1332 ..	4	13 77	9 1	2197	4	14 89	5 9	2769 .	3	14 52	6 9
1341 ..	4	14 64	8 5	2198	4	13 41	8 4	2774..	3	14 11	4 8
1354...	4	14 06	8 0	2200	4	14 61	5 1	2775	4	14 41	6 1
1392 ..	4	14 33	8 4	2214	4	14 92	7 9	2783..	4	15 15	8 9
1409 ..	4	14 91	9 5	2227	4	15 19	7 9	2799 .	4	14 10	9 0
1440	4	14 13	9 5	2230	4	14 91	9 1	2800 .	4	14 30	7 8
1441	4	13 96	9 5	2250	4	14 73	7 5	2801..	3	13 47	10 0
1442	4	13 46	9 5	2258	4	14 46	7 8	2802 .	4	14 40	8 0
1443	4	13 86	9 5	2261	4	14 30	8 0	2834	4	14 62	10 0
1444	4	13 96	9 5	2280	4	14 76	8 5	2836	4	14 88	10 0
1449	4	13 91	9 5	2297	4	14 44	8 5	2846	4	14 21	7 8
1501	4	14 13	8 7	2298	4	15 09	7 6	2847	4	14 63	6 0
1521	4	14 30	8 5	2319	4	14 21	7 3	2850	4	14 71	7 6
1535	4	14 81	7 5	2320	4	14 56	7 7	2855	4	14 51	8 0

TABLE II—*Continued*

Zone 5° to 10°—*Continued*

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
2857	3	14°92	6°6	3133	2	13°98	9°4	3460	4	14°61	8°2
2863	3	14.57	9.1	3136	2	15.62	6.3	3474	5	14.90	6.9
2864	3	14.52	5.5	3137	2	13.86	6.3	3493	2	14.37	6.0
2865	3	14.52	9.7	3138	2	13.98	8.7	3496	2	14.47	7.0
2867	3	13.88	6.7	3143	2	13.92	5.9	3497	2	13.31	9.6
2873	2	14.41	7.4	3175	2	15.08	8.3	3501	2	14.47	6.7
2891	2	14.51	6.7	3220	4	13.21	9.2	3563	2	14.50	7.9
2892	3	14.62	7.0	3228	3	14.34	6.4	3564	4	14.43	5.8
2901	2	14.63	5.7	3229	3	14.09	7.4	3566	2	14.41	5.8
2906	3	14.01	7.9	3230	2	14.88	8.4	3569	2	14.12	8.3
2907	3	14.58	5.2	3255	2	13.94	5.6	3585	2	15.29	10.0
2908	3	14.27	8.2	3261	2	14.21	8.2	3602	2	13.98	9.8
2910	3	14.42	7.0	3262	2	13.68	7.6	3605	2	14.18	9.8
2953	2	13.45	9.0	3269	2	14.86	9.2	3611	2	14.35	9.2
2957	3	14.98	6.4	3270	2	13.58	6.0	3619	2	14.75	6.9
2960	3	14.37	9.7	3271	2	14.50	7.7	3624	2	13.57	9.5
2961	3	14.88	7.7	3272	2	13.95	9.2	3632	4	14.71	6.8
2968	2	14.14	6.3	3282	2	14.41	10.0	3633	5	14.53	8.2
2969	2	14.44	8.7	3303	2	14.23	5.4	3662	2	13.09	6.5
2977	2	14.53	9.6	3304	2	15.29	5.1	3664	4	14.77	7.4
2979	2	13.74	6.0	3305	2	15.08	7.8	3667	6	14.60	9.0
2980	2	13.93	8.4	3328	2	13.27	7.3	3668	6	14.36	7.4
2982	2	14.51	8.6	3343	2	14.27	9.9	3729	3	15.28	8.0
2983	2	14.80	7.5	3354	4	14.22	9.5	3730	4	14.67	8.5
2984	2	13.92	7.3	3361	4	14.95	7.4	3735	4	14.71	8.6
2999	2	14.70	7.5	3362′	3	14.74	5.3	3737	4	14.43	8.5
3011	4	14.46	7.6	3354′	2	14.65	9.1	3742	4	14.48	7.5
3012	2	15.21	8.7	3359′	2	14.65	10.0	3743	2	14.53	8.8
3015	2	14.63	9.9	3360′	2	14.34	9.3	3744	4	14.93	7.1
3028	2	15.08	9.8	3370	7	14.29	7.0	3746	2	14.81	5.2
3029	2	13.89	7.5	3400	5	14.76	8.9	3753	2	15.01	9.4
3043	2	14.73	9.4	3401	4	14.78	9.2	3781	2	14.45	6.2
3046	2	14.30	9.3	3402	6	14.78	6.2	3782	2	15.26	6.2
3048	2	14.41	8.5	3403	2	15.34	9.8	3785	2	14.65	6.0
3049	2	13.98	6.1	3404	3	14.32	9.1	3786	2	14.75	7.2
3053	2	14.63	6.9	3405	3	14.71	5.3	3791	2	15.16	8.9
3070	2	15.36	9.8	3443	2	14.98	8.2	3795	2	13.95	7.1
3092	2	15.03	9.3	3457	3	14.38	7.1	3799	2	14.28	7.4
3123	2	14.48	9.3	3458	4	14.71	9.9	3800	2	14.97	5.1
3124	3	14.52	7.1	3459	3	14.53	8.8				

TABLE II—*Continued*

Zone −5° to −10° | Mean Latitude = −7°.71 | Mean Diurnal Motion = 14.52

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
96	4	14°.19	− 5°.6	2528	4	14.02	− 6.0	2967	3	14°.04	− 9.1
208	2	13.71	− 5.0	2529	3	14.27	− 7.1	2985	2	14.31	− 8.1
259	2	14.76	− 9.8	2564	2	14.27	− 9.2	2990	2	14.11	− 8.5
288	3	14.99	− 6.2	2565	3	14.43	− 5.0	2991	2	14.60	− 5.7
335	3	14.82	− 7.4	2578	3	14.58	− 7.7	2993	2	15.00	− 6.8
383	4	13.63	− 6.8	2580	2	14.56	− 5.7	2994	2	15.09	− 8.2
384	5	13.90	− 8.0	2581	3	14.79	− 6.1	3000	4	14.36	− 6.5
414	2	14.31	− 9.1	2630	2	15.17	− 7.8	3005	2	14.80	− 5.7
416	2	14.73	− 8.7	2634	2	15.06	− 8.9	3006	2	14.80	− 7.4
572	2	14.01	−10.0	2660	2	14.01	− 8.9	3007	5	14.71	− 5.2
579	2	15.11	− 5.5	2679	2	14.50	− 6.0	3010	4	14.23	−10.0
580	2	14.79	− 7.3	2680	4	14.74	− 6.8	3013	2	14.14	− 5.9
582	2	14.15	− 9.5	2682	4	14.85	− 5.7	3017	3	14.65	− 8.2
585	2	14.68	−10.0	2684	3	14.74	− 7.8	3020	3	14.16	− 9.9
734	3	14.47	− 5.1	2689	3	14.53	− 6.5	3021	3	14.51	− 8.0
868	6	14.12	− 6.8	2692	2	14.69	− 9.2	3022	3	14.85	− 7.1
887	3	13.96	− 8.3	2698	2	14.38	− 8.0	3025	2	14.58	− 9.9
886	3	14.05	− 6.6	2699	2	13.98	− 6.6	3034	2	14.68	− 9.9
889	2	14.15	− 8.0	2702	2	15.09	− 5.0	3081	2	14.72	− 6.7
1057	3	14.92	− 8.6	2711	2	14.32	− 8.5	3082	2	14.52	− 5.5
1065	3	14.67	− 8.3	2715	2	14.05	− 9.9	3087	2	14.41	− 6.3
1132	2	15.05	− 5.7	2717	2	14.52	− 9.1	3091	2	14.62	− 9.7
1165	2	14.29	− 5.8	2725	3	14.82	− 5.6	3098	4	14.45	− 8.9
1189	2	16.00	− 7.0	2732	5	14.15	− 6.7	3125	2	15.55	− 8.1
1258	2	14.35	− 9.0	2733	2	14.52	− 8.4	3126	2	14.65	− 7.2
1368	2	14.91	− 7.1	2734	4	14.48	− 8.6	3148	2	14.12	− 9.0
1470	2	15.93	− 8.0	2739	2	13.93	− 7.1	3149	2	14.05	− 9.3
1658	2	14.25	− 6.1	2740	2	14.71	− 8.2	3154	2	13.06	− 6.3
1701	3	14.05	− 8.5	2744	3	14.72	− 6.8	3170	2	13.06	− 7.0
1702	2	14.05	− 7.0	2756	3	15.19	− 7.2	3180	2	14.48	− 9.5
1752	2	14.49	− 9.5	2757	3	14.93	− 7.2	3181	3	14.44	− 7.0
1763	2	14.39	− 5.1	2766	3	14.67	− 5.5	3223	3	14.64	− 9.5
1769	2	14.99	− 8.8	2771	2	14.94	− 8.0	3232	2	14.07	− 8.7
1808	2	15.35	− 6.9	2777	2	14.11	− 8.1	3253	2	14.34	− 9.3
1809	2	13.23	− 9.4	2789	2	13.59	− 7.0	3286	2	14.50	− 6.7
1810	2	15.35	− 7.6	2790	2	14.00	−10.0	3319	2	15.08	− 5.8
1813	2	13.82	− 9.2	2814	2	14.33	− 7.0	3320	2	14.55	− 7.4
1950	2	14.01	− 8.7	2815	2	15.27	− 9.1	3321	2	14.76	−10.0
1991	2	14.97	− 9.7	2827	2	13.55	− 5.3	3322	2	15.40	− 8.1
2004	2	14.34	− 9.1	2826	2	14.22	− 8.1	3346	2	15.39	− 6.8
2069	4	14.35	− 7.7	2827	2	14.61	− 5.9	3355	3	15.29	− 6.0
2073	3	15.34	− 7.8	2829	2	14.51	− 7.9	3362	1	14.69	− 5.9
2076	3	14.63	− 9.1	2843	2	13.69	− 6.6	3364	3	14.09	− 7.9
2081	2	13.75	− 9.8	2885	3	14.92	− 9.9	3365	3	14.07	− 5.8
2082	2	13.88	− 8.7	2889	2	14.11	− 5.2	3377	3	14.72	− 6.9
2237	2	14.46	− 8.1	2898	2	14.93	− 8.9	3378	3	14.17	−10.0
2238	2	14.92	− 8.7	2903	3	14.37	−10.0	3391	3	14.37	− 8.6
2239	2	14.92	− 6.2	2917	2	14.19	− 8.2	3392	3	14.47	− 7.6
2285	4	14.25	− 7.0	2918	2	14.59	− 9.4	3408	3	13.92	−10.0
2325	4	14.47	− 6.3	2919	2	14.29	− 8.5	3419	2	14.56	− 8.9
2338	3	14.78	− 9.6	2921	2	14.09	− 6.8	3422	2	15.08	− 7.6
2344	2	15.58	− 8.7	2922	2	14.39	− 6.2	3433	4	14.37	− 6.0
2352	2	14.58	− 6.6	2923	2	14.39	− 5.7	3450	2	14.47	− 8.1
2417	4	14.29	− 9.8	2947	2	14.80	− 6.6	3451	2	14.26	− 9.0
2443	4	14.75	− 6.5	2958	2	14.60	− 7.4	3453	2	14.47	− 6.4
2448	4	14.32	− 9.5	2959	2	14.40	− 9.2	3462	3	14.59	− 8.8
2459	5	14.47	− 9.9	2936	2	14.43	− 5.7	3470	5	14.86	− 7.3
2505	3	14.93	− 7.9	2984	2	14.44	− 7.0	3487	1	14.74	− 5.0
2527	1	14.82	− 9.2	2984	3	14.84	− 7.9	3542	1	14.34	− 9.2

TABLE II—*Continued*

Zone −5° to −10° —*Continued*

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
3535	3	15°35	- 9°9	3648	2	14°66	- 9°9	3732	3	14°90	- 8.6
3536	2	14.62	− 7.8	3657	2	13.97	− 7.9	3760	3	14.18	− 7.7
3537	2	14.51	− 7.6	3663	7	14.38	− 6.7	3761	3	14.84	− 7.6
3540	4	14.50	− 8.0	3678	2	14.67	− 8.1	3762	3	14.64	− 7.7
3547	3	14.32	− 7.1	3680	3	14.96	− 8.4	3763	3	14.08	− 8.0
3554	2	14.94	− 5.5	3681	3	14 29	− 6.2	3767	5	14.42	− 5.8
3556	5	14.47	− 5.3	3682	3	14.33	- 6 1	3772	3	14.99	− 6.9
3561	2	14.12	− 9.7	3683	3	14 39	− 8.9	3778	3	14.87	− 9.6
3570	4	14.09	− 7.6	3692	3	15.02	− 9.8	3783	2	15.46	− 5.2
3572	2	14.79	− 8.0	3701	2	16.03	− 7.1	3794	2	14.75	− 9.0
3574	3	15.53	− 8.9	3705	3	14.70	− 7.4	3797	2	14.87	− 6.8
3608	2	14.18	− 5.4	3708	3	14.55	− 7.2	3808	2	14.67	− 8.9
3629	2	14.16	− 7.8	3709	3	14.75	− 8.5				
3630	2	14.35	− 8.6	3715	4	14.18	− 8.9				

TABLE II—*Continued*

Zone 10° to 15° | Mean Interval = 12°39 | Mean Diurnal Motion = 14°55

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
40...		15°24			3	14°64	14 2	1085	3	14°10	11°5
41...					7	14 10	10 2	1086.....	4	14.35	11.3
58...						14 36	10 4	1097.....	3	14.80	11.7
98...		14 55	12 1			14 18	12 3	1098	2	14.47	12.1
143...		14 69	14 6			14 28	13 9	1102.....	4	14.11	11.5
165...		14 88	10 4			14 87	14 1	1103	4	14.30	14.7
167...		13 96	14 0			14 66	11.9	1126	3	14.40	10 9
173...		15 08	12 0			14 24	12 5	1135	2	14.87	11.4
17...		14 97	11 4			14 88	13.5	1136	2	14 07	13.1
18...		14 60	12 9			14 47	10.1	1137	2	14 37	14 2
19...		14 60		715.....	3	13 76	14.5	1150	2	13 87	13.9
191..		13 96			3	14 34	14 4	1151.....	2	14.47	11.2
194..		14 70				14.29	14.6	1152.....	2	14.37	13.3
196..			14 1			14.39	14 4	1170.....	2	15 57	12.4
209..		14 70	13 1	771.....		13 93	14.2	1174	2	14.52	13.9
212..						14 74	13 5	1190	5	14.52	11 9
213..		14 33				14 13	12.7	1193..	3	13 89	12.1
214..		14 33				13.93	12.3	1199	3	13 74	14 2
227..						14 66	13.0	1207	3	14.02	14 6
252		13 90				14 05	11.2	1211	2	14.65	14.2
267..		14 41		805.....		15 69	12 0	1245	3	13 69	13.8
268..		12 74				14.34	12.6	1250	4	14.53	13 0
269..		13 98	11 9			14 36	10.4	1305	3	14.79	12 0
273..		14 55	10 9			12.60	12.0	1320	4	14 29	13.8
286..		13 95				13 83	12 4	1321	3	14 23	12 6
298..		14 08				14 68	12.9	1324	3	14 44	13.1
304..		13 97				13.95	15 8	1325.....	4	14 24	11.7
306..		13 54	12 5			13 78	13.1	1329	4	14.56	10 9
307..		13 76	11 2			14 25	10.3	1336	3	13.97	12 6
313..		14 84	13 9			14 55	11.2	1337	3	14.27	12.7
327..						14.59	11.2	1340	3	14.17	10 2
338..						14 08	19 9	1342.....	2	14.24	12.8
343..		14 13	14 4			14.21	13.3	1348	7	14.26	13.9
344..		14 37				14 67	10.7	1349	7	14 20	10.1
345.....		14 92				14.88	12.0	1350.....	7	14 55	14.9
350..		14 37				14.14	11.6	1356	6	14.40	12 3
361..		14 46	11 0			14 44	13.9	1410	2	14.61	11 1
363..		13 79	11 1			14.53	12.1	1414.....	2	13.53	12.3
364..		14 12	12 6			15 54	13 7	1416	3	13 27	12 4
371..		14 94	14			15 73	14 8	1417	3	14 04	14.9
385..			13			14 73	14.0	1439	2	15 90	10 2
387..		13 94	10			14 55	10 8	1442..	3	14 18	10 8
398..		14 44				13.65	13.7	1443	2	14 27	11.4
400..		14 16				13 72	11.2	1445	2	14 18	10.9
409..		14 02				13 87	14.2	1446.....	2	14.08	10.3
425..		14 01				13 77	10 4	1447.....	2	14 55	13 5
439			14 2			13 87	14 3	1450.....	2	13.81	12 2
448		14 90				14 22	12 5	1454.....	2	13.16	10 2
473		14 69	14 3			13 77	12 1	1502.....	3	14.47	11.9
482		14 44	12 2			14 25	11 7	1503	3	14 67	14.1
			10 4			14 37	11 9	1504.....	3	13 60	13 2
506						14 13	14 1	1511.....	2	15 04	14 6
511..			12 0			14 20	13 2	1519.....	2	13 65	12 8
513		14 31				13 70	10 7	1522.....	2	14 31	10 4
515							11 1	1523.....	2	14 22	14.1
516				1010			14 0	1524.....	2	14 78	15 0
		14 10		1092			12 4	1526.....	2	13 65	13 3
				1093			10 9	1527.....	2	14 12	13 6
		14 91	13 9	1050		14 52	11 9		2	13 94	12 0
			11 0	1051			11 9		2	14 15	12 6
			11 4	1054			11 9	1540.....	2	14 45	14 6
			11	1035		14 52	10	1544.....	2	13 58	12 5
			13 2	1060		14 47	11 6	1545	2	13 76	13 0
				1037		14 22	10	1547	3	14 13	12
			11	1095		13 83	14 5	1549	2	14 64	13 3
			11	1099			14 3	1550	2	14 64	15 0
			10 7	1061		14 72	11	1556	2	15 66	12 3
			11	1070		14 23	11	1557	2	14 55	12 7

TABLE II—*Continued*

Zone 10° to 15°—*Continued*

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
1558	2	14°.64	10°.1	2151	2	14.73	12°.3	2675	3	14.48	11.8
1559	5	14.11	14.5	2156	2	13.72	11.3	2695	2	14.29	10.7
1560	3	14.82	14.3	2158	2	13.59	10.4	2697	2	14.38	11.0
1561	5	14.13	12.2	2159	2	13.72	11.4	2706	2	14.41	12.6
1562	3	14.08	11.2	2160	2	13.97	13.7	2727	2	14.11	13.4
1565	3	14.37	13.5	2163	1	14.99	14.8	2728	1	14.04	14.4
1589	2	13.95	13.9	2165	2	15.20	12.6	2747	1	14.06	14.5
1598	4	14.29	11.2	2166	2	14.79	12.7	2765	3	14.47	10.5
1600	2	14.70	12.8	2170	2	14.89	15.0	2767	3	14.78	12.0
1609	5	14.50	11.6	2171	2	13.91	14.9	2772	3	14.83	13.0
1604	3	13.86	13.2	2172	1	14.06	12.2	2773	3	14.78	10.9
1622	3	14.19	12.2	2190	2	15.30	11.3	2784	2	14.92	11.6
1623	3	13.79	14.6	2191	2	14.99	10.6	2793	3	14.26	14.2
1627	3	13.81	11.2	2192	2	14.09	11.5	2794	2	15.11	11.7
1634	3	14.35	14.6	2215	2	15.47	14.6	2795	3	14.52	11.3
1635	3	14.40	13.5	2217	2	13.90	12.9	2801	3	14.47	10.0
1638	3	14.55	12.6	2221	2	15.10	12.7	2803	2	14.50	12.6
1645	2	14.33	12.0	2225	2	14.92	10.6	2804	3	14.62	10.0
1669	2	15.17	12.4	2252	2	13.65	12.2	2806	3	14.88	10.0
1670	2	14.44	11.2	2253	2	13.45	11.1	2809	2	14.96	10.6
1672	3	14.09	11.2	2255	4	14.28	11.1	2819	2	14.12	13.6
1679	3	14.24	13.0	2256	4	14.59	13.5	2820	2	14.41	14.9
1680	3	13.88	14.2	2258	2	14.01	14.0	2835	2	14.42	11.9
1696	2	13.82	13.5	2259	2	13.55	11.2	2836	2	14.01	12.1
1722	2	13.45	12.9	2289	6	14.20	13.6	2844	2	14.63	10.8
1723	2	13.65	14.2	2291	6	14.26	14.3	2845	2	14.42	12.2
1739	2	14.09	10.5	2293	6	14.18	13.0	2848	2	15.15	10.3
1740	2	14.19	11.9	2294	2	14.04	10.1	2851	2	14.42	11.6
1771	2	13.79	12.1	2295	2	14.24	11.9	2856	2	15.21	10.3
1795	2	14.49	10.0	2302	3	14.15	10.8	2858	3	14.33	11.5
1801	2	12.94	13.5	2251	3	14.54	11.4	2859	3	14.77	13.3
1802	2	14.14	10.1	2331	2	15.21	11.1	2860	3	13.78	11.9
1803	2	15.05	11.2	2332	2	13.72	15.0	2866	3	14.33	13.3
1807	2	14.34	15.0	2333	2	14.31	14.4	2870	3	14.28	10.9
1813	2	14.24	14.1	2366	3	13.74	14.0	2871	2	14.61	13.0
1831	2	14.34	10.2	2378	2	14.44	13.6	2874	2	14.71	14.0
1841	2	14.95	12.5	2383	2	14.97	10.9	2875	2	14.71	12.2
1851	2	14.44	10.7	2390	2	14.55	11.2	2894	2	14.63	12.0
1855	2	14.24	13.9	2391	2	14.65	10.7	2895	2	13.75	12.1
1905	2	14.46	11.0	2397	2	13.92	12.4	2896	2	14.54	11.9
1907	2	14.46	14.7	2398	2	14.13	11.3	2899	4	14.47	10.8
1912	2	14.65	10.8	2403	2	14.09	12.2	2902	2	13.95	11.4
1916	2	13.51	11.5	2404	2	14.59	14.8	2950	2	14.18	10.5
1919	2	15.31	12.2	2423	2	14.09	14.0	2954	3	13.99	12.9
1920	2	13.89	10.1	2462	2	13.95	13.0	2959	3	14.24	12.2
1921	2	14.93	13.9	2463	2	13.27	14.7	2973	3	14.81	11.9
1925	2	14.08	14.8	2464	4	14.49	13.1	2978	2	14.23	10.4
1952	2	13.91	14.0	2465	1	13.71	14.2	3014	2	13.85	10.2
1955	2	14.11	14.4	2482	2	14.75	12.7	3016	3	14.80	10.7
1956	2	14.62	12.4	2483	2	14.58	12.9	3023	2	14.92	10.1
1957	2	15.02	10.8	2509	5	14.59	11.8	3027	2	14.98	11.4
1959	2	14.01	14.5	2510	7	14.40	11.1	3030	2	14.78	13.2
1960	2	14.62	12.0	2513	4	14.63	13.1	3031	2	13.49	12.4
1981	2	14.36	14.2	2516	2	14.98	10.0	3032	2	13.49	12.6
1984	3	14.20	13.1	2539	3	13.65	11.6	3040	2	15.80	12.9
2015	2	15.10	10.4	2553	4	14.20	12.9	3041	2	15.05	12.5
2025	5	14.18	11.5	2554	2	13.94	14.3	3042	2	13.77	10.5
2027	5	14.28	11.9	2568	4	14.25	12.7	3044	2	13.98	11.0
2034	1	14.68	11.5	2569	3	14.32	14.2	3045	2	14.84	12.5
2038	3	14.65	14.2	2573	2	14.50	10.8	3047	2	13.98	10.3
2041	3	14.26	11.8	2574	3	14.17	13.4	3054	2	13.94	10.8
2055	4	14.45	10.7	2576	2	14.38	13.2	3107	3	14.63	11.6
2056	4	14.48	11.8	2582	3	14.25	13.9	3108	3	14.95	14.1
2058	2	14.28	13.7	2588	2	15.14	11.3	3109	2	14.72	13.5
2064	4	14.14	12.3	2589	2	14.83	11.9	3112	2	14.82	14.7
2077	3	14.28	14.2	2613	3	15.07	11.9	3113	1	14.52	13.4
2118	3	13.90	10.9	2653	4	14.70	10.8	3116	3	14.33	13.5
2136	2	14.01	14.8	2665	4	14.01	14.7	3117	3	14.39	10.8

TABLE II (*Continued*)

Zone 10 to 15 (*Continued*)

Number	Days	Diurnal Motion Sidereal	Heliocentric Latitude	Number	Days	Diurnal Motion Sidereal	Heliocentric Latitude	Number	Days	Diurnal Motion Sidereal	Heliocentric Latitude
3118	4	14°78	11°5	3345...	3	14.73	10°1	3587.	2	14°08	10.6
3119	4	14.78	11.8	3351'..	2	15.92	13.7	3588.	2	13.88	12.1
3127	4	14.68	11.1	3358'..	2	13.82	13.8	3595.	2	15.09	13.9
3128	2	14.56	15.0	3359'..	2	14.65	10.0	3599.	2	14.18	13.2
3129	2	14.33	14.6	3369...	6	14.29	13.6	3604.	2	14.68	12.7
3134.	2	14.09	13.5	3366...	3	14.32	11.2	3606.	2	15.09	13.1
3135	2	14.09	10.6	3367...	3	15.41	11.8	3612.	2	13.86	13.1
3136	2	14.88	11.2	3368...	3	14.52	12.9	3613.	2	14.06	14.4
3198	3	14.98	12.9	3398...	3	14.56	14.6	3615.	2	14.06	12.4
3210	3	13.94	14.8	3399...	2	14.88	12.2	3616.	2	14.75	13.5
3212.	4	14.62	10.7	3431...	2	14.06	10.2	3617.	2	14.16	10.8
3218.	2	14.89	13.3	3432...	3	14.10	12.6	3635.	2	13.66	11.2
3221	2	14.25	10.6	3438...	2	14.33	10.6	3669.	6	14.04	12.9
3224	3	13.85	12.3	3441...	3	14.33	10.5	3672	4	14.55	14.9
3225.	3	13.99	14.0	3445...	2	14.37	14.6	3673	3	14.34	14.9
3227.	3	14.74	11.5	3477...	3	14.53	11.1	3674	5	14.40	12.4
3256	2	13.94	14.7	3478...	3	14.17	11°6	3731.	4	15.08	11.1
3260.	2	14.07	14.8	3479...	2	14.24	11.2	3738	4	14.18	11.2
3263	2	13.81	10.4	3480...	2	14.46	13.1	3752.	2	14.49	10.8
3264.	2	14.07	12.4	3498	2	14.68	11.1	3755	2	13.77	10.1
3273.	2	14.50	11.6	3499...	3	14.47	10.1	3771.	3	14.38	13.8
3274.	2	13.95	14.6	3500...	3	14.22	11.5	3775	3	14.72	14.3
3275.	2	14.77	11.7	3510...	2	14.66	12.9	3776.	3	14.41	12.6
3276.	2	14.04	10.4	3567...	2	14.12	10.4	3787.	2	14.55	13.4
3277.	2	14.04	12.0	3568...	2	13.83	12.4	3788	2	14.55	13.9
3278	2	14.09	10.8	3578...	3	14.11	11.8	3790	2	14.25	14.8
3279	2	14.42	14.9	3581...	2	13.98	13.2	3796	2	14.35	13.2
3281.	2	13.98	14.3	3582...	2	14.18	13.6	3801.	2	13.88	13.2
3282	2	14.41	10.0	3583...	2	14.89	12.0	3804.	2	13.98	13.9
3284	2	14.18	10.4	3584...	2	14.08	12.8	3806.	2	13.88	14.9
3344.	3	14.84	10.4	3585...	2	15.29	10.0				

TABLE II—*Continued*

Zone −10° to −15° { Mean Latitude = 12.67
Mean Diurnal Motion = 14.43

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
177	2	14°85	−11°9	1347	2	15.24	−10°6	2339	2	14°26	−12°5
28	2	14.06	−12.7	1375	2	14.45	−13.2	2340	2	14.26	−13.5
225	5	14.19	−10.2	1376	4	14.45	−12.8	2345	3	14.37	−11.9
230	3	15.12	−10.3	1407	2	15.40	−13.6	2375	2	14.55	−12.9
233	2	13.94	−14.4	1430	3	13.89	−12.1	2376	2	14.55	−13.1
234	2	14.76	−12.8	1469	3	14.86	−12.9	2408	2	14.09	−14.6
237	3	14.54	−14.2	1471	3	14.09	−12.3	2411	2	14.29	−13.6
240	3	14.59	−14.3	1472	3	14.71	−14.8	2412	2	13.58	−12.9
248	5	14.00	−13.4	1476	3	14.95	−15.0	2422	2	13.78	−12.0
282	3	14.28	−12.2	1477	3	14.86	−14.5	2427	2	14.96	13.0
351	2	14.13	−14.3	1478	3	14.67	−11.4	2432	2	14.26	−14.3
380	5	14.33	−14.0	1486	2	13.75	−11.9	2456	4	14.54	−10.5
381	2	12.93	11.6	1487	3	14.43	−12.3	2457	4	14.43	−14.6
382	5	14.36	−11.5	1495	2	13.85	−11.0	2459	4	14.03	−14.7
401	3	14.76	−14.6	1496	2	14.01	−10.7	2469	1	13.95	11.0
403	2	14.44	−11.2	1513	3	14.43	−14.7	2492	2	14.65	13.4
412	3	14.32	−13.4	1517	2	14.31	−11.7	2493	2	15.17	−10.9
413	2	14.81	−13.8	1573	2	14.55	−11.9	2495	3	14.51	−12.5
415	3	14.37	−12.7	1584	2	14.25	−14.5	2497	3	14.77	−15.0
486	3	14.39	−12.3	1585	2	14.74	−13.6	2506	2	13.88	−12.8
522	2	14.42	−14.0	1599	2	14.99	−11.0	2524	6	14.04	−11.9
523	2	14.84	−14.6	1610	7	14.35	−14.6	2526	2	13.92	−13.5
524	2	14.84	−12.5	1616	3	13.54	−15.0	2531	6	14.18	−10.8
525	2	14.31	−13.4	1626	3	14.25	−12.6	2536	3	14.18	−13.0
562	2	14.01	−15.0	1660	2	15.72	−13.4	2542	3	15.00	−11.4
572	2	14.01	−10.0	1661	2	15.13	−12.8	2543	4	13.93	−10.9
585	2	14.68	−10.0	1713	3	13.89	−13.7	2545	4	14.85	−13.0
589	2	14.79	−14.7	1750	2	13.99	−14.2	2546	2	14.66	−11.0
594	2	14.68	−14.9	1751	2	14.39	−12.6	2547	2	14.55	−12.9
694	4	14.42	−12.0	1781	2	14.78	−13.2	2548	2	14.55	−12.5
695	2	14.02	−14.8	1811	2	14.24	−11.9	2557	4	15.04	−10.2
696	2	14.66	−12.0	1859	2	14.43	−14.1	2563	2	15.38	−12.5
697	2	13.81	−14.0	1860	2	14.23	−12.9	2579	2	14.61	−12.0
698	2	14.66	−10.9	1861	2	14.02	−11.2	2583	3	14.49	−10.8
704	2	14.02	−11.2	1862	2	13.62	−10.2	2604	2	14.12	−12.1
707	2	13.70	−13.5	1863	2	14.84	−13.6	2605	3	14.41	−13.0
727	2	14.24	−14.6	1865	2	14.64	−10.7	2606	3	14.65	−14.8
737	2	14.39	−13.5	1891	2	14.74	−14.1	2608	3	14.82	−14.2
738	2	14.39	−10.9	1900	2	14.93	−10.9	2626	2	15.17	−13.4
812	3	13.90	−15.0	1985	3	14.34	−11.9	2627	2	15.72	−10.9
815	2	14.48	−12.8	1992	2	14.46	−14.6	2629	2	14.73	−10.8
816	2	14.48	−12.2	2018	2	14.68	−11.7	2632	2	13.63	−10.9
817	2	14.68	−10.6	2026	2	15.20	−13.9	2633	2	14.51	−10.6
873	2	14.58	−13.3	2078	2	15.03	−11.8	2648	3	14.92	−12.1
897	3	13.67	−10.9	2079	3	14.29	−13.3	2652	2	14.53	−14.8
954	2	13.45	−14.7	2080	2	14.01	−11.4	2677	2	14.60	−13.9
1003	2	13.30	−14.6	2092	2	14.01	−14.9	2681	4	14.35	−11.0
1055	3	14.62	−14.0	2095	2	14.77	−13.9	2683	2	14.40	−12.2
1056	3	14.82	−10.2	2102	4	14.70	−13.7	2690	3	14.64	−11.5
1061	3	14.60	−11.7	2108	2	13.24	−11.9	2691	3	14.27	−13.6
1062	3	14.62	−10.5	2109	3	14.19	−14.3	2693	3	14.74	−14.1
1063	3	14.52	−12.5	2143	3	14.57	−14.6	2710	2	14.14	−13.3
1078	2	12.87	−13.4	2152	2	14.73	−10.2	2711	2	14.77	−14.4
1079	2	14.04	−11.5	2187	2	13.87	−14.2	2712	6	14.43	−11.8
1113	4	14.48	−14.8	2240	2	14.73	−12.6	2713′	2	14.59	−11.7
1114	3	13.95	−12.9	2245	2	13.72	−13.9	2716	3	14.61	−12.8
1146	2	14.77	−13.7	2278	2	13.45	−12.2	2718	3	14.52	−11.0
1147	2	14.37	−14.4	2280	4	13.75	−15.0	2720	3	15.02	−13.9
1162	2	13.89	−13.1	2282	4	14.50	−14.7	2723	2	14.83	−13.5
1164	2	14.84	−10.4	2286	2	14.54	−10.3	2737	2	13.53	−12.6
1166	2	13.78	−10.6	2288	2	14.93	−10.5	2725′	2	14.42	−10.2
1167	2	14.73	−12.1	2315	6	14.41	−15.0	2758	3	14.88	−11.3
1168	2	15.04	−10.4	2316	4	14.40	−11.6	2759	3	14.68	−13.8
1230	2	13.84	−14.7	2324	3	14.69	−10.9	2760	3	14.16	−14.7
1242	2	14.95	−12.8	2326	2	14.61	−12.5	2761	3	14.52	−14.2
1283	2	13.85	−13.8	2329	2	14.31	−11.1	2762	2	14.63	−11.5
1288	2	15.06	−15.0	2335	2	14.87	−13.4	2763	2	15.35	−12.7
1346	7	14.32	−14.0	2337	3	14.88	−13.7	2780	2	14.31	−12.3

TABLE II (continued)

Zone +10° to +17° (inclusive)

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
[illegible]	2	13°39	−14°3	3206.....	3	14°14	−14°9	3513.....	2	13°46	−11°1
[illegible]	2	14 41	−14 8	3207.....	2	14 01	−13 3	3514.....	3	14 70	−10 7
[illegible]	2	14 10	−10 4	[illegible]	2	14 21	−15 0	3524.....	2	14 98	−13 8
2786.....	[illegible]	[illegible]	−10 2	[illegible]	2	14 21	−15 0	3525.....	2	15 35	−10 9
[illegible]	[illegible]	14 21	[illegible]	[illegible]	2	[illegible]	−13 5	3526.....	3	14 65	−11.2
[illegible]	2	[illegible]	[illegible]	[illegible]	2	13 94	−10 2	3548.....	2	14.82	−14 6
[illegible]	3	14 88	[illegible]	[illegible]	2	[illegible]	−14.1	3549.....	3	14 26	−12.9
2830.....	2	13 74	−12 7	[illegible]	2	14 55	−13 1	3553.....	2	14.74	−11.7
2831.....	2	14 32	−12 2	3298.....	2	14 23	−10 2	3573.....	2	14.79	−11 8
2903.....	[illegible]	14 37	−10 0	3321.....	2	14 76	[illegible]	3575.....	3	14.57	−14.8
[illegible]	[illegible]	14 58	−10 6	3327.....	2	14 55	[illegible]	3576.....	3	14.62	−14 1
[illegible]	2	[illegible]	−12 1	[illegible]	[illegible]	14 94	−12 4	3590.....	2	14 48	−11 0
[illegible]	[illegible]	14 75	−10 8	3332.....	[illegible]	14 83	−14 2	3631.....	2	15 33	−14 8
[illegible]	2	14 50	−10 9	3333.....	3	15 00	−11.0	3639.....	3	14.77	−13 8
2936.....	2	[illegible]	−13 4	[illegible]	[illegible]	14 51	−10 6	3641.....	6	14.71	−14 7
2938.....	2	[illegible]	−10 7	[illegible]	[illegible]	14 77	−11 2	3643.....	6	14 29	−10 8
[illegible]	2	[illegible]	−12 3	3336.....	3	14 47	−14.1	3652.....	2	14 46	[illegible]
[illegible]	2	14 60	−12 2	[illegible]	3	15.21	−15 0	3654.....	4	13 98	−14.4
[illegible]	[illegible]	13 55	−14 1	[illegible]	3	[illegible]	−13.3	3655.....	4	14 35	−13 6
[illegible]	[illegible]	13 94	−10 3	3361'.....	3	[illegible]	−13 0	3659.....	2	14.66	−14 4
2966.....	[illegible]	14 33	−12 8	3363'.....	3	14 54	−13.8	3660.....	2	13.78	−14 6
2975.....	2	14 13	−15 0	[illegible]	2	13 50	−13.4	3675.....	4	14.77	−12 1
2976.....	[illegible]	[illegible]	−12 8	[illegible]	2	14 65	−14.0	3676.....	5	14.72	−10 2
[illegible]	2	14 13	−12 8	[illegible]	2	13 71	−10.1	3677.....	2	14.03	−10 8
[illegible]	[illegible]	15 09	[illegible]	[illegible]	[illegible]	14 44	−11.4	3684.....	2	14.78	−12 7
[illegible]	2	14 21	[illegible]	3378.....	[illegible]	[illegible]	−10 0	3689.....	2	14.35	−13 3
[illegible]	[illegible]	14 37	−13 9	[illegible]	[illegible]	14 47	−14.8	3690.....	2	14 35	−10 9
3010.....	[illegible]	14 23	−10 0	[illegible]	[illegible]	14 67	−11 1	3691.....	3	14 13	[illegible]
[illegible]	[illegible]	13 77	−14.9	[illegible]	3	14 72	−12.5	3693.....	[illegible]	14 58	−11 6
3024.....	[illegible]	14 56	[illegible]	[illegible]	[illegible]	14 57	−13 3	3694.....	[illegible]	14 44	[illegible]
[illegible]	[illegible]	[illegible]	−13 1	[illegible]	[illegible]	13 98	−12.5	3695.....	2	15 00	[illegible]
[illegible]	2	14 68	[illegible]	[illegible]	2	13 27	−10.5	3700.....	2	14 93	−12 8
3037.....	[illegible]	13 59	[illegible]	3408.....	[illegible]	13 92	−10 0	3702.....	2	14.73	−14.7
3079.....	2	14 41	−11.4	3409.....	2	14 27	−12.6	3706.....	5	14.44	−14 6
3080.....	2	15 64	[illegible]	3410.....	2	15 24	−13 8	3710.....	6	14 62	−14.6
3084.....	2	14 52	[illegible]	[illegible]	[illegible]	14 69	[illegible]	3713.....	4	14 43	−13 4
3093.....	2	14 41	−11 2	[illegible]	2	15 05	−11.5	3714.....	2	14 48	−11 1
[illegible]	[illegible]	14 [illegible]	[illegible]	3423.....	4	14 41	−10 9	3720.....	6	14 21	[illegible]
3147.....	2	13 92	[illegible]	3428.....	2	14 88	−12 5	3724.....	2	15 10	−14 2
[illegible]	2	15 13	−12 8	[illegible]	3	14 54	−14 1	3725.....	2	14.70	−14 1
[illegible]	2	13 99	−13 1	[illegible]	3	14 78	−13 3	3726.....	2	15.10	−11 3
3169.....	2	[illegible]	−13 2	3463.....	4	[illegible]	−12 2	3741.....	2	14 53	−12 1
3172.....	2	14 41	[illegible]	[illegible]	3	13 81	−14 3	3768.....	3	14 69	−11 5
3187.....	2	14 18	−15 0	[illegible]	2	14 85	−11.7	3769.....	3	15 19	−13 0
[illegible]	[illegible]	14 [illegible]	−14 4	[illegible]	3	14 38	−14 1	3807.....	2	13.78	−10 6
[illegible]	2	14 78	−12 5	[illegible]	[illegible]	14 91	−10.1				
3196.....	2	13 48	−11 7	[illegible]	[illegible]	14 03	−14.5				

TABLE II *Continued*

Zone 15 to 20 — Mean Latitude = +17°39
Mean Diurnal Motion 14°24

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
42	2	14°73	15°5	358	3	14°19	17°8	708	5	13°89	18°4
43	2	13.84	15.4	359	5	14.55	18.0	709	6	14.39	17.5
44	2	14 22	19 2	360	3	14.19	16.1	713	5	14.54	19 6
47	2	14.73	20 0	365	3	14.35	16.5	714	3	13 86	15 9
48	2	14.22	15 9	369	3	14 39	17.0	716	2	14 34	19.5
53	2	14.22	19 9	370	3	14.30	17.7	719	2	14.14	16 0
56	2	15.24	18.5	373	2	13.79	19.1	721	1	14.40	17.0
59	2	14.89	17.6	388	3	13.58	15.3	722	1	14.31	18.3
60	2	14 89	18.6	389	3	14 24	16.7	723	2	14.24	17.5
61	2	14.76	19.3	394	2	14 06	17.5	739	2	14 09	18 8
69	3	14.69	16.3	399	1	14 15	18.0	744	2	13.99	16.7
70	2	14.26	15.9	422	4	13.98	19 1	756	2	14.01	19.3
78	2	14.15	19.4	423	5	14.03	15.4	760	2	13.89	18.7
120	2	15.17	17.1	424	2	14.12	19.0	768	2	13.93	19 6
132	3	14.40	19.1	425	2	14.01	15.0	770	2	13.93	16 8
138	3	14.11	19.9	427	6	13 78	18.9	775	2	14.43	19.8
145	3	13.36	19.3	430	6	13.63	18.4	776	2	13.53	17.1
153	3	14.23	18 7	433	2	13.71	18 1	788	2	13.93	17.3
154	3	14.30	15 6	434	2	13.91	17.3	793	2	14.56	19 3
155	3	14.34	17 2	442	2	14.02	16.2	796	2	14 87	17 2
156	3	13.93	17.7	443	4	13.92	17.6	798	5	14 41	15 4
161	3	14.33	18.3	449	2	15.16	16.2	799	2	14.56	16.6
162	2	14.62	19.8	450	2	15.16	17.8	801	2	12 92	19.8
163	2	13 70	17.0	456	2	15.28	19.3	804	2	14.87	16.8
168	3	14 85	17.2	457	2	15 54	18 3	806	2	14 87	17 9
171	3	14.32	17.3	458	4	14.43	20.0	828	1	14 26	19 6
172	3	14.15	17.0	488	2	14 65	19.2	829	4	14 29	16.7
185	2	14.13	15.4	489	2	14.45	18.9	832	2	13.92	16 5
186	2	15.15	19.6	492	2	14.32	17.2	833	2	14.01	17.9
189	2	13 92	17.9	493	2	14.62	18.3	834	2	14.39	16 5
14	3	14.60	17.1	494	2	14.43	18.1	835	2	13.83	19.1
15	3	14 46	16 6	495	2	14.82	16.2	836	2	13.73	19 5
16	3	14.10	16 5	497	2	14.32	17.1	837	1	14.48	15.3
20	3	14.64	20.0	499	2	14.72	18.5	838	2	14.48	19.6
36	2	14.33	19.0	504	2	14.95	15.4	839	2	14.48	16.1
190	2	14.33	18 0	505	2	15.16	16.0	842	2	14.01	15 5
193	2	13.83	17.5	507	2	14.42	15.1	843	2	13.83	16.9
194	2	14.70	15.0	510	2	14.20	16 3	844	2	13.73	18.9
195	2	14.20	15.7	512	2	14.52	18.0	852	3	13.95	15.3
197	2	13 96	18.8	514	2	13.89	17.8	853	3	14.42	16.9
201	2	13.46	18.3	526	2	13.77	18.9	861	4	13.91	15.4
202	2	13.83	19.6	535	2	15.19	15.3	862	3	13.85	17 2
210	2	14.08	16.9	536	2	14.55	17.9	865	4	14.23	18 7
211	2	13.59	17.3	539	2	14.01	17.6	892	3	13.90	17.8
212	2	13.46	15.0	544	2	14.01	19.7	908	2	14.43	18 8
215	2	15.19	17 0	600	4	14.46	15.5	909	2	14.63	19.6
216	2	14 08	15.5	601	2	14.15	19.0	910	2	14.73	17.6
223	2	13.83	17.1	602	2	14.15	17.6	914	2	13.83	17.2
224	2	13.83	17.6	603	2	14.15	16.0	917	2	14.03	17.7
226	3	13.96	16.4	604	2	13.72	15.5	918	2	14.63	17.7
229	5	14.22	16.6	605	2	12.66	19.7	921	2	14.43	16 0
270	2	13.98	16.2	608	3	14.43	18.3	922	2	14.23	18 8
271	4	14.22	15.8	609	2	13.93	15.2	923	2	14.13	18.5
284	3	14.44	19 6	613	2	13.30	18.2	924	2	14.33	15.7
287	3	13.53	16.7	637	4	14.28	16 6	935	2	14.63	15.7
296	2	13.86	16 1	641	2	14.15	15.6	960	2	13.95	16.7
297	2	13.86	17.3	642	2	14.26	16.8	962	3	14.12	18.8
302	3	14.34	15.5	650	2	13.94	17.4	964	3	13.62	16.3
303	2	12.56	17.9	658	2	14.53	19 8	965	3	13.72	18.9
310	3	13.74	18.0	663	3	14.64	18.1	966	3	14.27	19.7
311	4	14.45	15.7	675	5	14.18	16.1	970	2	15.15	17.2
312	4	14.36	15.9	676	5	14.25	17.4	973	3	14.17	18.4
314	2	14.73	16.3	677	3	14 15	17.3	982	2	13.25	15.1
315	2	13.65	17.3	678	3	13.98	17.4	990	2	13.50	19.7
316	4	13.76	15.1	679	5	14.00	17.8	992	2	14.60	19.6
317	2	14.51	17.5	687	5	14.13	16.7	997	2	14.00	19.7
326	4	13.86	16.0	691	5	13.97	18.0	1000	2	13.70	17.7
328	2	14.19	18.7	692	2	13.91	16.3	1023	2	14.83	16.4

TABLE II—*Continued*

Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude
1071	1	14°08	18°3	1436	2	14°18	18°3	1917	2	14°17	15°5
1082	1	14 42	15 3	1438	2	14 18	15 1	1918	2	15 41	17.7
1080	1	14 37	15 1	1444	2	13 81	17.0	1922	2	14 27	18.7
1041	1	14 08	16 8	1448	2	14 73	19 8	1923	2	13 89	20 0
1052	1	14 77	18 8	1459	2	13 81	18.9	1926	2	13 98	16 0
1065	3	14 08	19 1	1461	2	14.55	19.6	1927	2	14 08	18 0
1068	3	14 [illegible]	15.0	[illegible]	2	14 45	17.8	1942	2	14.11	19 9
1048	1	14 01	17 8	[illegible]	2	13 62	17.5	1944	2	14 62	15.1
1088	1	14 13	16 0	[illegible]	3	14 09	19 7	1945	2	14.42	17.0
1089	1	13 75	19 [illegible]	1507	2	13 85	19 5	1946	2	15 02	18.3
1071	2	15 12	19 7	1508	3	14 76	17.5	1949	2	14.92	18 2
1089	3	14 55	18 6	1509	3	14 47	17.0	1950	2	14 11	18 2
1091	1	14 50	18 8	1510	2	14 94	19.7	1951	2	14 11	15 1
1087	1	14 02	19 0	1524	2	14 78	15 0	1962	2	13 31	16 8
1089	1	14 80	16 0	1525	2	14 78	16 8	1965	2	14.52	17 9
1100	3	13 89	18 3	1528	2	13.56	18.9	1967	4	13.89	18 8
1126	2	13 94	16 4	1541	2	14 74	19.1	1968	3	13.85	17 5
1124	2	13 45	16 4	1542	2	14 25	19.1	1969	2	14 25	18 2
1130	1	14 30	15 7	1543	3	13 83	18.6	1975	2	13.54	19.1
1107	1	14 07	18 7	1536	3	14 28	15 8	1982	4	14.19	18 5
1149	2	14 07	15 5	1548	2	14 15	15.7	1983	2	14 66	15 5
1171	2	14 77	17 7	1550	2	14.64	15 0	2009	2	13.87	19 4
1172	2	14 [illegible]	19 9	1564	2	14 45	15.3	2010	6	13 71	19 3
1173	2	14 [illegible]	17 7	1566	5	14 17	16.3	2019	2	13 96	16 9
1175	2	14 [illegible]	17 8	1567	3	13 53	17 5	2020	4	13.99	20 0
1178	2	14 63	19 8	1569	2	13.85	18.0	2021	2	13.85	19.1
1177	2	13 47	17 0	1570	3	13 93	17.8	2042	6	14.44	15.1
1195	1	14 [illegible]	16 9	1588	3	14.37	15.8	2043	4	14.32	17.7
1198	1	13 [illegible]	16 4	1590	2	14 01	16.4	2044	6	13.77	17.5
1199	1	13 44	19 2	1591	2	13.42	15 3	2045	4	13.86	16 0
1212	2	14 35	15 5	1608	7	13.60	16.4	2070	2	14.80	16 2
1213	2	14 [illegible]	16 2	1611	3	14.41	16.7	2085	2	14 65	15.1
1214	2	14 15	18 4	1612	5	13 75	16.2	2089	2	14.90	17.2
1215	2	15 05	17 6	1628	3	14.15	19.7	2127	4	13.65	19.3
1216	2	15 65	18 9	1633	3	14 40	17.3	2129	4	13 82	18.5
1217	2	13 84	16 8	1636	3	14 01	16 0	2130	4	14 23	15 5
1218	2	13 84	19 3	1642	2	14 63	18.3	2134	3	15 06	18.1
1221	2	15 75	16 1	1643	2	13 73	17.0	2135	2	14.52	17.0
1240	2	14 35	17 4	1644	2	14 83	15.4	2141	3	13.74	16.8
1248	1	14 43	19 1	1649	2	14 23	17.3	2164	2	14.59	15 4
1247	1	14 27	17 4	1667	2	14 65	15.3	2167	2	14.89	18 6
1251	1	13 94	15 6	1668	3	14 34	17.3	2170	2	14.89	15 0
1252	1	14 48	17 1	1671	3	13 84	15.5	2173	4	14 01	18.7
1256	1	14 41	18 9	1674	3	14 55	17 8	2174	2	15 20	19.7
1261	3	14 53	18 0	1675	3	14 45	18 4	2188	4	14 00	20 0
1262	2	13 95	17 6	1676	2	14 24	19 4	2189	2	13 57	17 2
1268	2	14 95	18 2	1678	3	13 94	16 4	2201	4	14.07	16 7
1301	3	14 74	15 1	1681	3	14 04	15 3	2202	4	13 66	16 8
1315	7	13 85	18 0	1684	2	14 75	18 9	2203	4	13 67	16 8
1350	2	13 65	18 6	1719	2	14 85	15.1	2204	4	14.09	19 6
1360	1	14 15	17 3	1755	2	14 69	19 3	2207	3	13.86	16 5
1376	1	14 37	17 4	1756	2	13 39	18 2	2212	3	14 31	18 2
1391	1	14 08	19 9	1762	2	14 39	15 2	2210	2	14.64	17.4
1366	4	14 16	18 2	1801	2	14 04	18 1	2218	2	15 38	17.1
1366	1	14 11	17 3	1805	2	14 44	15 6	2219	2	15 01	17.0
1408	1	14 26	18 3	1806	2	14 44	15 9	2220	2	15 10	16 9
1470	1	14 52	17 3	1807	2	14 34	15 0	2232	2	15 29	15 5
1366	1	14 [illegible]	17 7	1814	2	15 01	16 1	2223	2	14 64	19 8
1366	1	14 [illegible]	18 2	1816	2	14 14	20 0	2225	2	15 01	17.1
1367	1	14 [illegible]	18 7	1819	2	14 44	18 8	2249	4	14 89	16 6
1411	1	14 41	17 1	1824	2	14 34	17 9	2250	4	13 98	18 6
1415	1	14 [illegible]	15 3	1850	2	14 04	19 7	2251	4	14.03	16 7
1416	1	14 [illegible]	19 3	1853	2	14 34	16 6	2257	2	13 94	16 5
1419	1	14 [illegible]	17 2	1861	2	14 23	16 2	2261	2	14 54	19 2
1420	1	14 81	16 6	1866	2	13 72	18 6	2280	6	13 93	18 1
1430	1	14 [illegible]	[illegible]	1846	2	14 08	19 1	2292	4	13 99	16 9
1427	1	14 55	18 8	1841	2	14 17	19 4	2300	4	14 10	18 8
1431	1	14 [illegible]	17 5	1814	2	14 65	19 9	2302	4	14 30	16 2

TABLE II—*Continued*

Zone 15° to 20°—*Continued*

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
2328	2	14°31	17°2	3050	2	14°20	17°0	3417	2	15°21	16°9
2332	2	13 72	15.0	3110	4	14.64	19.4	3425	2	14.16	18.1
2365	3	14.15	15.9	3111	4	14.16	16 6	3434	4	14.44	18.4
2384	4	13 52	18 5	3114	3	15.09	18.5	3436	2	14.33	17.0
2385	2	14 02	20 0	3115	3	14.49	16.1	3439	3	13.76	15.1
2392	4	13 92	18.9	3128	2	14.56	15.0	3440	3	14.49	16 6
2416	2	14 19	15 5	3130	2	14.21	15.2	3442	3	14.49	17.9
2466	2	13 17	18.1	3131	2	14.09	17.0	3455	2	14.67	15.4
2533	2	14 98	15.1	3132	2	14.92	12.3	3475	3	14.73	18.2
2538	2	14 51	15 9	3151	2	14.92	18.0	3476	5	14.84	19.6
2570	4	14.45	15.8	3184	2	13.57	18.3	3481	3	14.79	15.5
2571	2	14 00	17.5	3199	6	14.26	15.1	3482	2	14.85	17.7
2575	2	14.38	16.7	3200	3	14.28	17.2	3490	4	13 82	19.2
2577	2	13 72	19.3	3201	2	14.28	18.5	3491	2	14.41	19.0
2590	2	12.86	15 4	3211	4	14.16	15.6	3506	3	13.88	15 7
2591	2	14.73	15.8	3216	2	14.57	17.0	3507	3	14 81	15.7
2635	2	15.61	16.9	3219	2	14.14	15.1	3550	3	14.34	15.3
2636	2	14.51	18.2	3222	2	14.14	17.6	3579	2	13.58	18.5
2707	2	14.68	18.2	3226	3	14.24	16.8	3580	2	14.28	16 5
2729	2	14.32	17.7	3257	2	14.34	17.9	3596	2	13.88	16.8
2730	5	14.25	15 3	3259	2	14.07	19 8	3598	2	13.88	15.2
2750	2	13 39	20 0	3265	2	13.81	17.5	3610	2	14.38	16.5
2751	2	13.58	19.8	3267	2	13.81	17.5	3614	2	14.35	17.7
2752	2	14.25	15 8	3280	2	14.50	15.8	3634	2	14.54	18.4
2791	2	14.40	17 9	3306	2	14.02	15.1	3670	6	14.27	17.2
2792	2	14.30	15.7	3308	2	14.55	17.0	3671	3	14.34	19.0
2796	3	14.27	16.0	3309	2	13.81	15.9	3696	2	14.03	17.2
2797	2	15 41	17.7	3310	2	13.91	17.9	3697	4	14.28	17.3
2798	3	14.88	17.9	3311	2	14.65	18 2	3711	2	14.12	19 3
2821	2	14.51	15.4	3312	2	14.55	16 2	3712	2	14.63	18.4
2837	2	14 84	15.7	3341	2	13.93	17 8	3765	3	14.23	17.6
2838	2	14.11	16.5	3356′	2	14.44	16 5	3766	3	14.29	15.6
2872	2	12.81	18.1	3357′	2	13.40	16 5	3770	3	14.33	15.3
2897	2	14.14	15.6	3394	4	14.50	16 2	3789	2	14.35	15.8
2925	2	15.08	17.0	3395	4	14.34	18 7	3802	2	13.68	16.3
2955	2	14.93	15.9	3396	2	14.68	18.6	3803	2	13.78	16.0
2956	2	14.73	15.5	3397	6	14.29	18.9	3805	2	14.18	15.5
3033	2	13.99	15.3	3415	4	14.38	16.7				

TABLE II (continued)

[illegible] = −17°.58
[illegible] = 13.45

Number	Obs.	Diurnal Motion Sidereal	Hour Angle at Transit	Number	Obs.	Diurnal Motion Sidereal	Hour Angle Latitude	Number	Obs.	Diurnal Motion Sidereal	Hour Angle Latitude
37	2	14°48	−17°5	569	2	14°87	−18°4	1076	2	[illegible]	−16°3
[illegible]	[illegible]	14 86	−18 0	571	2	14 87	−17 0	1077	2	14.43	−19 6
[illegible]	[illegible]	14 89	[illegible]	577	2	13 62	−19 2	1111	2	[illegible]	−16 1
[illegible]	[illegible]	15 02	−19 9	578	4	14 25	−16 2	1112	4	14 69	−17 7
[illegible]	[illegible]	[illegible]	−17 2	583	4	14 32	−15 8	1120	4	14 03	−18.5
[illegible]	[illegible]	14 33	−17 5	584	2	13 83	−19 0	1132	2	14 67	−17 6
[illegible]	[illegible]	14 40	−20 0	590	2	13 83	−19 0	1159	2	14 20	[illegible]
80	3	14 34	−17 5	618	2	13 35	−18 3	1160	2	14 84	−18 4
[illegible]	3	13 82	−19 5	619	2	13 35	−17 9	1161	2	14.73	−18 7
[illegible]	[illegible]	[illegible]	−15 3	629	2	14 20	−19 0	1169	2	14 42	−17.1
[illegible]	[illegible]	14 43	−15 7	630	6	14 78	[illegible]	1191	3	14 73	[illegible]
[illegible]	3	13 19	−19 2	631	2	14.49	−17 2	1197	3	14.42	−20 0
11	3	14 [illegible]	−15 5	632	2	14 12	−16 3	1200	[illegible]	13.52	−17 3
13	3	13 64	−16 7	681	2	14 37	[illegible]	1223	2	14.55	−19 4
25	2	14 51	−18 7	693	2	14 77	−15 1	1224	2	14.15	−16 9
26	2	12 98	−15 7	699	2	14 02	−17 [illegible]	1225	2	13 64	−16 5
217	2	15 56	−18 4	700	2	13 27	−19 6	1226	[illegible]	[illegible]	−15.1
218	2	14 70	−17 8	702	2	14 02	[illegible]	1227	2	13 74	−18 1
232	[illegible]	14 57	−19 9	724	2	14 54	−19 2	1241	2	13 24	−15 1
241	[illegible]	13 86	−17 7	725	2	14 65	[illegible]	1245	2	15 05	−17 2
[illegible]	[illegible]	14 76	−16 7	726	4	14 57	−19 4	1258	4	14 07	−17 2
250	[illegible]	14 [illegible]	17 0	728	2	13 94	[illegible]	1259	4	14.16	−17 3
268	[illegible]	14 93	−19 3	729	4	14 21	[illegible]	1260	4	14 07	−19 8
[illegible]	[illegible]	14 01	−17 9	733	2	13 84	−15.9	1263	4	14 34	−18.8
240	[illegible]	14 12	−16 8	735	2	14 89	−17 8	1282	2	14 95	−18 3
242	[illegible]	14 11	−19 7	736	2	13 89	−16 8	1285	2	14 25	−20 0
244	[illegible]	14 39	−20 0	738	2	14 01	−19.9	1287	2	14 17	−18 9
244	[illegible]	13 94	−19 8	763	2	14 43	−19.7	1288	2	15 06	−15 0
[illegible]	[illegible]	14 21	−16 4	764	2	14 43	−17 6	1289	2	14.27	−16 3
[illegible]	[illegible]	14 08	−18 4	777	2	13 63	−15 9	1301	3	13 92	−16 4
275	[illegible]	[illegible]	−19 2	792	2	14 [illegible]	−17.9	1302	2	13 97	−15 5
[illegible]	[illegible]	14 40	−14 8	812	3	13 90	[illegible]	1304	2	15 26	−17.1
[illegible]	[illegible]	14 42	−17 3	814	2	13 92	−16 2	1355	3	14 26	−17.4
[illegible]	[illegible]	14 62	−16.6	818	4	14 21	−15 6	1374	4	14.26	−18 8
[illegible]	[illegible]	13 97	−19 6	819	2	14 01	−16 5	1377	4	14 17	−15 8
332	[illegible]	14 64	−17 4	849	4	14 11	−19 5	1378	4	[illegible]	−17 5
[illegible]	[illegible]	14 71	−18 1	850	3	14 06	−19.9	1379	4	14 41	−19 3
[illegible]	[illegible]	14 44	−15 8	855	3	14 61	[illegible]	1380	4	14 80	−17.7
[illegible]	2	13 47	−19 2	857	3	13 74	[illegible]	1382	4	[illegible]	[illegible]
[illegible]	[illegible]	14 47	−17 3	877	2	14 15	−17.8	1385	[illegible]	14.19	−19 4
[illegible]	[illegible]	14 79	−18 9	879	3	14 11	−16 0	1394	[illegible]	[illegible]	−15 4
374	[illegible]	13 89	−16 8	881	2	14 15	[illegible]	1400	2	14 22	−20 0
375	[illegible]	14 98	−18 1	888	2	13 56	−15 9	1401	2	14 51	−16 9
[illegible]	[illegible]	13 47	−15 7	898	3	14 03	−17 8	1406	2	14 32	−16 0
386	[illegible]	14 44	−17 5	900	4	13 84	[illegible]	1426	[illegible]	14 50	−15 1
[illegible]	[illegible]	[illegible]	−18 5	902	4	14 56	[illegible]	1428	[illegible]	13 94	−18 4
[illegible]	[illegible]	14 57	−18 1	903	2	13 13	[illegible]	1429	[illegible]	14.40	−17 2
[illegible]	[illegible]	[illegible]	−15 6	926	2	14 13	−19 6	1434	[illegible]	[illegible]	−15 7
[illegible]	[illegible]	[illegible]	−18 4	932	2	14 04	−19 8	1436	[illegible]	13 25	−17 8
[illegible]	[illegible]	14 72	−17 0	939	4	14 23	−18 5	1445	2	14.36	−18 5
410	[illegible]	14 42	−18 1	942	2	15 23	−18 5	1458	2	14.45	−16 9
417	[illegible]	14 73	−16 6	943	2	15 33	−19 0	1467	2	13 53	−17 0
418	[illegible]	14 32	[illegible]	944	2	14 33	[illegible]	1468	[illegible]	14 08	−15 1
[illegible]	[illegible]	14 01	−15 5	945	[illegible]	[illegible]	−16 8	1473	3	[illegible]	−17 7
[illegible]	[illegible]	[illegible]	−17 9	947	[illegible]	[illegible]	−17 1	1475	3	13 89	−19 8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13 07	−18 7	1479	3	14 95	[illegible]
471	[illegible]	14 15	−17 0	[illegible]	2	13 55	[illegible]	1479	3	14 91	−17 5
[illegible]	[illegible]	[illegible]	−18 4	952	2	13 45	−19 1	1480	3	14 33	−18 0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	13 95	[illegible]	1485	[illegible]	13 85	[illegible]
[illegible]	[illegible]	[illegible]	−16 1	[illegible]	2	12 89	−15 7	1494	[illegible]	13 85	−17 2
527	[illegible]	[illegible]	[illegible]	[illegible]	3	13 83	−16 2	1516	2	14 40	−15 6
545	[illegible]	[illegible]	−18 9	[illegible]	[illegible]	14 22	−16 1	1527	[illegible]	14 40	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1058	[illegible]	[illegible]	−15 6	1574	3	14 62	−15 2
554	[illegible]	[illegible]	−19 5	[illegible]	[illegible]	[illegible]	−17 2	1575	[illegible]	13 98	−16 1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	−17 3	1591	[illegible]	14 60	[illegible]
582	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	−15 2	1615	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	−17 0	1616	[illegible]	13 54	−15 0
[illegible]	[illegible]	[illegible]	−16 0	[illegible]	[illegible]	[illegible]	[illegible]	1651	3	14 14	−19 7

TABLE II—*Continued*

Zone −15 to −20 *Continued*

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
1618	3	14°39	−18°5	2112	4	14°47	−15°8	2489	3	14°51	−18°1
1650	2	12 84	−17.8	2113	2	13.75	−16 2	2491	2	15.06	−18.9
1662	2	15.33	−19.0	2114	4	14.17	−16 3	2494	2	14.96	−15 3
1664	2	14.13	−19 4	2115	4	14.42	−19 0	2497	3	14.77	−15 0
1665	2	15.23	−17.7	2137	3	15.02	−17.8	2498	3	14.15	−16 8
1704	2	14.86	−15.9	2138	2	13 24	−19 2	2500	3	14.41	−19.9
1714	3	14.29	−17 0	2140	2	14.87	−18.2	2501	3	14.51	−16 5
1715	3	13.99	−17 0	2142	3	14.76	−16.8	2502	2	14.13	−17 8
1716	2	14.44	−17 6	2144	3	15.13	−19.3	2503	3	14.46	−17.1
1718	3	14.90	−17.7	2147	2	14.47	−15.8	2512	4	14.11	−18.5
1721	2	14.85	−17.7	2149	3	14.47	−19.4	2515	3	14.28	−19.0
1727	2	13.75	−20 0	2178	2	13.87	−19.3	2520	2	14.40	−16.8
1729	2	13.15	−17.0	2241	2	13 53	−16.4	2522	2	14.60	−17.8
1731	2	14.15	−15 8	2242	2	14.55	−17.2	2523	6	14.53	−17.1
1745	2	14.19	−16.8	2243	2	14.64	−16.4	2525	4	14.13	−15.3
1747	2	14.39	−17.4	2244	2	14 27	−16 3	2530	6	14.19	−15.7
1748	2	14.19	−18 4	2246	2	12.89	−15 9	2534	2	14.42	−17.5
1749	2	14.89	−16 1	2247	2	13.90	−18.8	2535	5	13.92	−18.7
1753	2	13 49	−17 5	2264	2	14.93	−19.5	2537	3	14 01	−15.4
1767	2	14.09	−18 2	2266	2	14.34	−16 9	2544	2	14.32	−18.6
1768	2	13.69	−19 0	2271	4	14.25	−17.2	2552	3	14.55	−19.4
1772	2	14.97	−18 2	2272	4	13.74	−17 0	2556	3	14.99	−15.1
1773	2	14.00	−17 1	2276	2	14.14	−16.1	2559	2	15.16	−18.7
1774	2	13.81	−17 6	2277	2	13 65	−17.1	2560	3	15 22	−16 8
1777	2	15.07	−19 9	2280	4	13.75	−15 0	2562	3	13 76	−15.8
1778	2	14 39	−18 0	2281	4	14.71	−16 4	2595	6	14.67	−17 4
1779	2	14 39	−16 1	2283	4	14.36	−16 9	2596	2	14 00	−19.1
1780	2	14.29	−17 6	2284	4	14.70	−18 5	2600	3	15.12	−19 9
1782	2	14.39	−16 3	2287	4	14.19	−19.4	2602	3	14.82	−18 8
1785	2	14.78	−18 6	2312	3	14.53	−18.4	2603	3	14 65	−15.2
1787	2	14 20	−19 4	2313	4	14.50	−17.8	2607	3	15.04	−17.5
1789	2	14.20	−18.1	2314	4	14.49	−15.4	2609	2	14.62	−17.0
1812	2	13.94	−17 0	2315	6	14.41	−15.0	2616	2	14.87	−18.2
1856	2	14.33	−17 4	2321	4	14.46	−17.9	2619	2	15.19	−15.7
1857	2	14 02	−17 6	2322	2	13.62	−17.1	2620	2	14.71	−18.1
1858	2	14.74	−16 1	2323	2	13.32	−17.2	2628	2	15.83	−15.3
1866	2	14.64	−16 3	2336	3	14.58	−16.2	2647	2	15.14	−15.6
1876	2	14.74	−19.1	2341	2	14.36	−18.1	2694	2	15.34	−19.2
1880	2	13.92	−17 6	2346	2	14.97	−16.8	2708	2	14.41	−15.6
1881	2	15.04	−18 6	2347	2	14.77	−18.2	2709	2	14.68	−16.0
1882	2	14.23	−19 8	2347	2	14.67	−16.5	2713	2	14.14	−17.4
1885	2	14 02	−18.7	2348	3	15.13	−19.2	2721	2	14.62	−15.7
1886	2	14.74	−16 8	2342′	3	13.97	−17.6	2722	2	15.03	−15.8
1887	2	14.94	−17.1	2351	2	14.28	−15.4	2724	2	15.96	−17.4
1888	2	13.92	−18.9	2353	2	14.28	−19.4	2741	4	14.07	−19.1
1892	2	14.36	−15.4	2357	6	14.55	−15.6	2748	2	13.87	−15.2
1996	2	13.85	−20 2	2361	5	14.52	−17.4	2753	2	14.06	−19.0
2013	6	14.61	−17.7	2362	3	14.30	−16.7	2755	3	13.40	−16.9
2028	2	14.89	−19 1	2363	3	13.69	−18.4	2778	2	14.11	−15.6
2027′	2	15.31	−17.2	2367	2	15.50	−16.8	2779	2	14.41	−15.8
2031	4	13.98	−18.4	2368	2	14.34	−16.1	2818	2	14.13	−17.4
2068	2	14 91	−17.3	2370	2	14.76	−20 0	2832	2	14.32	−15.4
2083	3	14 37	−16.8	2371	2	14.65	−17.6	2878	2	14.51	−19.9
2084	3	14.02	−19 5	2372	2	14.65	−17.2	2882	2	15.21	−16.9
2086	2	14 90	−17 2	2373	2	14.55	−15.5	2883	2	14.21	−16.4
2088	4	14.33	−18.9	2401	4	14.91	−18.3	2884	2	15.01	−18.3
2093	4	14.38	−15 6	2409	2	14.59	−15.5	2905	3	14.06	−19.5
2094	3	14.23	−17.7	2413	2	13.68	−17.6	2911	2	14.88	−18.2
2098	2	13.24	−18 0	2429	2	14.36	−17.9	2912	2	14.49	−15.4
2099	2	13.24	−19.8	2430	2	14.06	−18.8	2913	2	15.68	−19.5
2101	2	14.39	−16 6	2433	2	14.96	−19.7	2914	2	15.48	−17.1
2103	4	14.18	−15.4	2458	2	14.76	−16 1	2930	3	14.09	−17.3
2104	2	13.75	−18 9	2460	2	13.96	−18 9	2931	3	14.33	−18.9
2105	4	14.29	−17 3	2470	2	13.07	−16 1	2932	2	14.50	−16.2
2106	2	13.24	−17.9	2472	3	14.85	−18.4	2939	2	14.20	−19.2
2107	2	14.13	−19.8	2473	3	14.09	−19 9	2942	2	13.93	−19.1
2110	3	14.60	−19.7	2477	3	14.25	−18 4	2943	2	14.02	−15.3
2111	4	14.76	−17.9	2486	3	14.87	−15 5	2974	3	14.73	−15.9

TABLE II—*Continued*

Zone +15° to −20° Continued

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
2975.....	2	14 14	−15°0	[illegible]	4	14 46	−16°4	3380	2	13 97	−17°0
2981'.....	2	14 [illegible]	[illegible]	[illegible]	4	14.82	−16.8	3386	2	14 88	−18.3
2987	2	14 60	−15 3	[illegible]	3	14.34	−16.7	3411.....	2	15 14	−16 4
2988	2	14 80	−15.4	[illegible]	2	14.34	−17.4	3412	2	15 24	−19.7
2996.....	4	14 08	−17 3	[illegible]	2	14 21	−15 0	3414	2	14 17	−15 2
2998.....	2	13 62	−18 6	[illegible]	2	13 16	−18.9	3464	2	14.45	−17.4
3035.....	2	14 38	−16 9	3238.....	2	14 47	−19.8	3465	3	14.17	−16.4
3038.....	2	13 89	−18 6	3246.....	2	13 03	−19 8	3502.....[	3	14 22	−17.6
[illegible]	2	15 73	−19 1	[illegible]	2	14 21	−15 0	3503.....[	2	15 21	−19.3
3056.....	2	14 33	[illegible]	[illegible]	2	13.16	−16 6	3511	2	14 38	−18 0
3057.....	4	14 19	−15 3	[illegible]	2	13 16	−15.2	3512.....[	2	15.40	−18.3
3060.....	2	15 13	−19 8	[illegible]	2	14 86	−16 6	3515	4	14 67	−15 6
[illegible]	3	14 03	−18 [illegible]	3284.....[	2	15 05	−19 5	3516	2	14 79	−18 9
3065.....	2	14.93	−19 7	[illegible]	2	13.95	−19 7	3518	3	14 21	−19 3
3073.....	2	15 [illegible]	[illegible]	[illegible]	2	14.22	−19 7	3527.....	5	14 69	−15 4
3074.....	2	13 70	−16 8	[illegible]	2	13 77	−16 9	3543.....[	2	14 21	−18 1
3075'.....	2	14 92	−19 7	[illegible]	2	13.49	−18.5	3553.....	2	14 32	−17 0
3077.....	2	14 31	−18 0	[illegible]	2	14.23	−17.7	3571.....	2	14 31	−19 1
3078.....	2	15 13	−19 9	[illegible]	2	14 87	−18 2	3577.....	3	13 86	−17.2
[illegible]	2	14 31	−16 8	[illegible]	2	14 44	−17 6	3589.....[	2	14 38	−19.4
3086.....	2	14 31	−16 2	[illegible]	2	14.34	−17.9	3593.....[	2	14.08	−18.5
3102.....	4	14 73	−18 3	[illegible]	2	14 31	−18 0	3625.....	2	14.45	−17.3
3106.....	2	15 82	−18 8	[illegible]	2	14.12	−18 3	3626.....[	2	14.16	−16 3
3122.....	3	14 24	−18 9	3337.....	4	14.45	−16 9	3640.....	4	14 88	−16.4
[illegible]	2	14 80	−18 2	[illegible]	4	14 50	−18 6	3658 ..[	2	14.96	−16 8
[illegible]	2	13 92	−16 6	[illegible]	2	14.87	−18 5	3661 ..[	2	14 46	−17.5
[illegible]	2	13 72	−18 7	[illegible]	3	14.94	−19 8	3688	4	13.86	−19 4
[illegible]	2	14 41	−16 0	[illegible]	2	14 61	−16 6	3716.....[	5	14 18	−15 5
3153.....	2	14 30	−16 6	[illegible]	4	14 12	−18.7	3721	4	13.82	−17.8
3157.....	2	14 20	−19 2	3353.....[	3	14 54	−16 1	3722.....	2	14.70	−19 6
3162.....	2	14.10	−19 2	3357.....[	3	14 96	−18 7	3723.....	2	14 20	−18 2
3166.....	2	13 78	−18 9	[illegible]	3	15 21	−15 0	3736 .[	2	14.11	−16.9
3186.....	2	15 70	−19 3	3359.....[	2	14 61	−15 4	3751 .[	2	13.90	−19.7
3187.....	2	14 18	−15 0	3343'.....	2	14.23	−17.1	3774	3	14.08	−19.6
3188.....	2	14 68	−18 8	3345'.....	2	14.03	−19.3	3809	2	14 57	−16 6
3193...	2	14 98	−17 0	3346'	2	13 61	−19 3	3810.....	2	14.77	−16.1
3202.....	3	14 17	−19 2	3347'.....	2	13.92	−15.1	3811.....	2	15.27	−16 5
3203.....	3	14 37	−19 2	[illegible]	2	14.13	−19 4				
[illegible]	2	14 48	−16.6	3379.....	3	15.21	−18.5				

TABLE II *Continued*

Zone 20° to 25° Mean Latitude +22°.22
Mean Diurnal Motion 14°.05

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
45	2	14°.35	23°.5	346	2	13°.47	21°.1	916.	2	14°.23	22°.6
47	2	14.73	20.0	347	2	14.03	20.8	919.	2	14.23	24.5
49	2	14.22	22.3	348	2	15.03	21.0	920.	2	13.13	24.8
62	2	13.88	21.9	366	2	13.90	21.5	967.	3	13.92	22.6
63	2	13.37	24.0	367	2	14.12	20.4	991.	2	13.50	22.1
65	2	14.13	23.4	368	2	14.09	23.7	998.	2	14.40	21.7
66	2	14.64	20.9	372	2	13.69	20.2	999.	2	13.90	22.2
68	2	13.74	24.3	378	2	14.01	24.8	1006.	3	13.32	21.8
74	2	13.74	22.2	395	4	14.06	20.6	1015.	3	14.63	23.5
75	2	13.62	24.0	396	2	14.35	22.0	1016.	3	12.62	22.2
88	3	13.93	24.2	397	2	13.87	22.7	1018	3	13.32	24.4
89	3	13.89	20.5	411	3	13.51	21.0	1025.	4	14.05	20.9
90	2	13.24	24.8	428	6	13.56	22.0	1045.	2	14.12	23.2
99	3	14.61	22.1	429	2	13.50	20.2	1047.	2	14.83	20.8
100	3	14.78	23.2	431	2	13.40	23.5	1072.	2	13.26	22.9
101	3	14.21	25.0	432	2	14.01	21.5	1088.	3	14.60	20.4
109	2	14.38	22.6	435	2	12.88	22.9	1090.	4	13.98	20.9
110	2	14.11	20.1	437	2	14.14	22.0	1092.	4	14.02	22.8
118	2	14.51	23.0	440	2	14.90	21.0	1093.	4	14.28	21.1
124	2	13.58	22.5	441	2	13.76	24.5	1094.	4	14.34	20.1
131	3	14.42	20.3	444	4	14.08	20.6	1096.	2	14.88	22.1
133	3	13.76	22.1	445	2	14.40	21.0	1131.	2	13.94	23.9
134	3	14.65	24.0	446	2	14.65	21.5	1134	2	13.57	24.0
135	2	14.36	24.5	447	2	14.78	23.4	1138.	2	13.97	23.8
136	3	14.34	20.7	453	2	15.03	24.3	1187	2	15.78	24.4
137	3	14.10	20.8	454	2	14.78	21.5	1196.	3	13.94	20.9
139	2	14.09	23.1	455	2	14.52	20.2	1219.	2	14.65	21.1
140	3	13.82	23.1	458	4	14.43	20.0	1220.	2	14.75	21.6
149	3	14.43	23.2	476	2	14.15	23.2	1222.	2	14.35	21.8
150	2	13.83	22.1	490	2	14.13	23.2	1235.	2	14.35	22.7
151	3	13.83	20.3	491	2	14.13	20.8	1236.	2	13.44	20.8
152	3	13.82	21.6	496	2	15.02	20.4	1239.	2	13.84	21.3
157	2	14.36	22.9	498	2	14.13	20.6	1248.	4	14.31	24.0
158	3	14.81	22.4	500	2	13.64	21.2	1249.	4	14.33	22.8
160	2	14.75	22.6	503	2	14.73	20.1	1255.	4	14.01	21.2
169	2	13.57	22.8	508	2	14.31	22.6	1271.	2	13.95	25.0
187	2	14.74	20.8	540	2	14.01	22.0	1344.	2	13.95	20.9
188	2	14.43	23.2	541	2	13.80	23.0	1359.	7	13.94	21.9
20	3	14.64	20.0	542	2	14.65	23.5	1360.	5	14.15	22.4
21	3	13.82	20.2	574	2	13.69	21.1	1362.	3	14.52	22.2
22	2	14.24	22.5	575	2	13.37	23.6	1363.	2	13.44	25.0
29	2	14.60	20.4	606	2	13.83	20.8	1364.	2	12.64	20.2
34	2	13.52	23.2	607	6	14.23	21.7	1365.	3	15.08	23.7
35	2	14.24	22.9	611	2	14.04	20.9	1369.	2	13.74	21.2
32	2	14.13	22.3	612	2	14.15	23.2	1371.	4	14.21	22.6
33	2	14.68	23.5	624	2	13.54	24.4	1372.	3	13.81	23.3
192	2	14.45	22.0	625	3	14.03	21.7	1387.	4	14.21	24.2
198	2	15.06	20.8	643	2	14.26	24.2	1388.	4	13.62	22.9
200	2	13.83	25.0	651	2	14.63	21.5	1389.	4	14.33	21.3
203	2	13.46	20.5	653	2	13.94	24.6	1390.	2	13.84	20.2
204	2	13.96	24.9	664	3	14.17	22.6	1391.	4	14.29	24.6
207	2	13.71	21.2	745	2	14.29	22.7	1413.	2	14.12	23.6
228	2	13.75	23.1	746	2	14.19	22.9	1423.	3	14.19	21.1
250	2	13.57	21.8	759	2	14.71	20.6	1424.	3	13.58	24.0
251	2	14.12	20.2	767	2	14.23	22.4	1437.	2	13.99	21.8
256	2	14.12	22.8	774	2	14.33	22.1	1449.	2	14.08	20.3
280	3	14.18	22.3	786	2	14.13	23.0	1460.	2	12.88	21.5
285	3	13.83	23.5	794	4	14.11	23.6	1506.	3	14.04	22.5
301	2	14.08	22.2	803	2	14.05	25.0	1512.	3	13.74	21.1
308	4	14.04	21.9	863	3	13.96	22.3	1529.	2	13.56	20.9
309	4	14.33	20.5	864	3	14.16	20.1	1530.	2	14.22	21.5
318	4	14.00	21.8	866	4	13.62	22.7	1531.	2	14.40	21.2
319	2	13.97	21.6	867	2	14.38	24.3	1551.	2	15.14	23.5
325	2	13.97	20.8	893	5	13.59	23.2	1552.	2	13.95	22.0
330	3	13.47	20.9	896	3	13.81	23.7	1555.	2	14.25	20.5
334	3	14.27	24.5	899	3	13.81	21.4	1564.	3	13.53	20.5
337	2	14.13	20.5	901	4	13.80	24.5	1568.	3	13.88	21.8
341	2	14.48	24.8	915	2	14.43	20.4	1596.	4	13.95	24.9

TABLE II—Continued

[Long. 30° = 2h—Continued]

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
[illegible]	4	13°91	[illegible]	1869	2	13°41	23°9	2200	4	13°96	20°8
[illegible]	3	14 01	25 0	[illegible]	2	14 23	24 9	2205	3	13 11	22 3
1606...	1	[illegible]	24 1	1871.....	2	13 62	23 0	2210	3	14 06	21 6
1624...	1	[illegible]	21 4	1909	2	14 36	21 6	2211	3	13 31	20 2
1629...	1	[illegible]	[illegible]	1910	2	13 60	20 8	2224	2	14 27	23 8
1630..	4	13 49	22 1	[illegible]	2	13 89	20 0	2233.....	2	13 72	20 3
1631...	4	14 01	[illegible]	[illegible]	2	14.27	21.8	2262.....	4	13 85	21.5
1632..	3	14 50	[illegible]	[illegible]	2	13 41	21 3	2265	4	14 26	24.5
1641...	2	13 54	20 5	[illegible]	2	14.31	23 7	2385.....	2	14 02	20 0
1647	2	14 24	21 7	1972.....	2	14 77	23 3	2386	4	13 58	20 8
1648	2	14 03	21 7	1974	2	14 25	20 1	2394.....	2	12 97	23 2
1677	2	14 13	20 1	1977.....	4	14.13	21 1	2572	2	13 72	25 0
1682	3	13 13	21 5	1978	6	13 81	24.4	2584	3	13 84	22 7
1684	3	14 16	25 0	1986	3	13 67	23 2	2585	3	13 90	21 8
1686	2	13 72	24 6	1987.....	2	14 36	24 5	2637.....	2	14.18	20 9
1692.....	3	13 43	23 0	2003.....	3	13.71	24.4	2638.....	2	14 51	23 8
1693	2	14 44	23 5	2011	6	13 84	23.1	2664.....	3	13 92	22 4
1694	3	14 34	20 9	2017	2	13 85	22 4	2749.....	2	13 77	21 8
1695.....	3	13 76	20 1	2020.....	4	13 99	20 0	2750.....	2	13 39	20 0
1697	3	13 84	20 7	2026	4	14 02	23.7	2822	2	13 64	21 1
1729	2	13 75	21 1	2040	4	13 96	22 4	2839.....	2	13 69	23 8
1734.....	2	14 49	21 5	2041	2	14 59	21.5	3217.....	2	14 04	20 4
1757.....	2	13 79	22 4	2045	2	14 59	22 7	3258	2	13 55	21 6
1768	2	13 99	22 3	2123	2	13 88	23 7	3266	2	14 07	20 3
1769	2	13 09	21 9	2125	2	13 62	21 9	3307	2	14 76	21 9
1813	2	14 34	24 3	2126	2	14 65	20 5	3393.....	3	14 02	20 9
1816	2	14 14	20 0	2128.....	2	13 37	20 7	3416.....	4	14 09	21.1
1817.....	2	14 14	22 1	2131	2	14 13	23.7	3437	2	14 33	23.5
1818	3	14 64	23 1	2132.....	3	14 02	21 0	3564	2	13 84	21 3
1820	3	14 08	20 7	2133	2	15 29	21 2	3562	2	13 63	20 8
1821.....	2	14 14	20 4	2148	2	14 06	21 1	3597.....	2	13 88	21.7
1823	2	14 14	22 5	2154.....	2	13 47	20 2	3601	2	13 98	21.1
1824	3	14 74	24 9	2155.....	2	14 86	23 9	3636	2	13 76	23 3
1828.....	2	13 94	22 7	2162	2	14.35	21.6	3698	3	14 15	22 0
1830	3	14 84	24 6	2188	4	14 00	20 0	3719.....	2	14 07	21 0
1867	3	14 23	23 3	2199.....	4	13 78	21.3				

TABLE II—*Continued*

Zone −20 to −25 Mean Latitude = −22°.19
Mean Diurnal Motion = 14.19

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
38	2	14°99	−23°0	633	2	14°20	−23°5	1233	2	13 14	−23°5
50	2	14.73	−23.8	634	2	13.72	−22.9	1256	1	14 98	−24.7
51	2	14.48	−25.0	635	2	14.49	−22 2	1257	4	14 56	−21.2
52	2	13 20	−21.9	680	3	14.11	−21.6	1261	1	13 99	−24.5
57	2	14 89	−22 2	682	2	14.18	−22 8	1262	4	14.19	−24.0
71	2	15 14	−20 2	703	2	15.84	−20.7	1264	4	14.40	−20.5
72	3	14.58	−21.3	729	3	14.21	−20.0	1266	2	14.05	−22.6
79	2	14.40	−20 0	730	3	13.36	−23 6	1268	2	16.35	−24.8
114	2	14.24	−24 0	731	4	14 22	−20.7	1269	2	15.75	−24.4
178	2	13 61	−22.4	732	4	14.49	−20 8	1280	2	15.65	−22.3
4	3	14 28	−23.9	741	3	14 50	−22 9	1281	2	14.65	−21.3
6	2	14.24	−23 9	749	2	13.79	−23.1	1284	2	14.65	−22.9
7	2	14.33	−24.3	761	2	13.93	−24.0	1285	2	14.25	−20.0
8	2	14.06	−20.6	762	2	13.63	−23.1	1286	2	13.55	−23.7
9	2	13.61	−20.2	765	2	14.84	−22.8	1290	2	14.47	−22.8
10	2	14.15	−22.6	779	2	14.13	−20 6	1291	3	13.59	−24.7
12	3	14.05	−22.3	780	2	13.83	−22 9	1294	3	14.03	−22 8
30	2	14 31	−24 1	787	2	14 03	−23 6	1295	3	14.08	−22 9
219	2	14 08	−22 2	811	2	13 54	−24.7	1300	2	13.18	−22.7
235	2	14.40	−20.8	821	2	14.30	−24.4	1334	3	13.42	−24.0
243	3	14.39	−20.0	822	4	14.59	−20.5	1335	3	13 82	−24 6
245	3	14.73	−20.3	826	2	14.48	−21.5	1381	3	14.32	−20.5
246	2	13.94	−21.4	848	3	13.95	−22.3	1383	4	14.26	−21.5
254	2	13.57	−21.6	856	6	14.52	−22.1	1384	4	14.10	−20.6
255	3	13.90	−20 9	878	3	14.68	−24.4	1399	2	14.51	−20.4
266	3	14.04	−21.7	880	3	14.20	−21.3	1400	2	14 22	−20.0
263	2	14.08	20 6	883	3	14.29	−25 0	1404	2	14.12	−23.8
264	2	13.87	−21.7	884	3	14.06	−22.1	1427	3	14.55	−20.7
265	2	14 91	−20 8	887	2	14 05	−21.2	1435	3	14.24	−23.8
276	2	15.11	−20.1	894	2	14.33	−21.2	1464	2	13.81	−21.1
281	3	12.82	−22.6	904	4	14.19	−21.0	1474	3	13.32	−21.5
291	2	13.65	−22.1	906	3	13.62	−20.8	1481	3	13.65	−23.2
292	2	14.19	−24.0	925	2	14.53	−22.5	1482	3	14.57	−20.5
293	2	14.84	−23.1	927	2	14.53	−22.1	1483	2	13.55	−24.2
331	3	14.34	−22.9	930	2	14.43	−23.8	1484	3	14.48	−22.0
420	2	13.91	−21.5	931	2	14.03	−24.8	1489	3	14.62	−24.2
436	6	14.17	−22.5	946	2	13.05	−24.3	1490	3	14.34	−23.2
459	2	14.14	−24.8	948	2	13.65	−21.1	1491	2	14.84	−20.3
461	1	13.80	−22.3	951	2	13.25	−24.7	1493	2	13.85	−24.1
462	1	14.01	−20.5	953	2	13.95	−20.0	1474′	2	13.56	−20.6
466	3	14.69	−20 2	955	3	14.12	−21.3	1518	2	13.56	−21.3
468	3	14.84	−23.3	956	3	13 87	−20.6	1576	5	14.10	−24.9
469	3	14 09	−23.6	1052	3	13.98	−20.3	1578	3	14.08	−22.9
470	2	14 55	−23.4	1053	3	14.27	−22.1	1592	2	14.79	−21.7
471	2	14 65	−22.9	1054	3	14.77	−23.9	1655	2	14.03	−22.1
478	2	14.05	−24.5	1075	2	14.04	−22.3	1663	2	13.73	−21.4
501	2	14.52	−24.8	1081	2	13.75	−23.3	1666	2	13.24	−23.9
502	2	14.43	−21.2	1104	2	14.88	−23.0	1703	3	14.75	−20.6
520	2	14.20	−23.5	1105	4	13.90	−23.6	1717	3	14.40	−21.7
528	2	13.99	−21.3	1107	4	14.11	−22.1	1727	2	13.75	−20.0
547	2	13.90	−24.1	1109	4	13.99	−24.2	1728	2	13.75	−22.0
548	2	13.80	−22.7	1121	4	14.54	−20 1	1730	2	14.15	−21.2
551	2	14.33	−23.1	1122	4	13.87	−23.1	1743	2	14.49	−22.0
552	2	13.90	−22.8	1143	2	14.27	−22.1	1744	2	13.99	−20.4
556	2	14.87	−22.8	1144	2	14.77	−21.4	1746	2	14.19	−22.1
557	2	14.65	−23.6	1153	2	13.87	−21.7	1765	2	14.09	−20.9
561	2	14.98	−23.1	1154	2	12.57	−21.4	1770	2	12.59	−20.5
563	2	13.48	−21.1	1158	2	14.10	−21.7	1775	2	13.52	−24.4
564	2	13.90	−22.5	1163	2	12.74	−21.5	1776	2	14.39	−21.1
566	2	14.01	−21.0	1197	3	14.42	−20 0	1783	2	14.20	−21.7
570	2	14.44	−20.5	1198	3	14.25	−20 5	1784	2	14.10	−21.9
576	2	14.47	−23.0	1202	3	14.95	−24.4	1786	2	14.59	−20.1
586	2	14.04	−24.9	1204	3	14.95	−21.0	1788	2	14.10	−22.0
588	3	13.57	−22.2	1206	3	13.83	−24.5	1873	2	14.23	−24.6
591	3	13.73	−22.5	1228	2	14.75	−20 9	1875	2	14.53	−21.9
595	3	13.88	−20.4	1229	2	14.35	−22.3	1877	2	13.62	−23.4
615	2	14.57	−21.2	1231	2	14.15	−22.5	1878	2	13 92	−23.6
621	3	13.77	−23.1	1232	2	13.34	−20.5	1889	2	14 23	−21.9

TABLE II—*Continued*

Zone 20° to 25° (continued)

Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude
1804	2	14°08	-20°0	2517	2	14°69	-24°2	3161.	2	13°58	-23°3
1804	2	13 70	-20 3	2518	2	14 21	-21 8	3167.	2	13 68	-22 1
1805	2	13 98	-23 9	2521	2	13 92	-21 2	3168.	2	13 27	-20 2
1930	2	13 31	-23 1	[illegible]	6	14 22	-21 7	3191.	2	15 79	-24 5
1960	3	13 87	-20 1	2558.	3	14 27	-21 8	3192.	5	14 06	-24 5
1965	2	14 15	-20 3	2561.	2	14 27	-21.1	3205.	2	14.28	-22 4
1995	2	14 66	-23 0	2586	2	13.17	-23 6	3214.	2	14 79	-22 8
2013	3	13 01	-22 3	2587.	2	14 83	-21 4	3215.	2	12 75	-21 0
2030	4	12 98	-21 5	2597.	2	14 42	-23 1	3237.	2	13 81	-21 5
2032	3	13 62	-23 3	2598	4	14 34	-23 4	3239.	2	13 29	-21 5
2060	2	14 38	-22.4	2601.	3	15 07	-21.5	3240.	2	14 47	-23 1
2087	3	13 73	-23 5	2615.	2	15 03	-21.5	3241.	2	13 16	-24.8
2090	3	13 89	-23 3	2617	2	14 71	-20.4	3244.	2	13 81	-23 5
2091	4	14 14	-21 1	2726	2	14 71	-23.0	3245.	2	13 29	-20 1
2099	2	14 39	-20 1	2742	2	14 03	-22 3	3292.	2	13 86	-20 7
2097	4	14 44	-23 2	2743.	4	14 28	-20.6	3293.	2	14.41	-20 9
2100	4	13 86	-22 2	2745.	4	14 62	-24 6	3295.	2	14.50	-21 0
2139	2	13 49	-20 7	2746.	4	14 19	-21.1	3299.	2	14 76	-20 2
2145	3	15 08	-21 1	2754	2	13 87	-21 0	3325.	2	14 02	-20 7
2150	2	14 73	-24 9	2788.	3	14 98	-20 8	3349.	3	14 85	-23 9
2155	3	14 78	-21 7	2816.	2	14 33	-21.7	3350	3	14 20	-22 1
2170	2	13 26	-24 1	2817.	2	14 23	-21.3	3344′	2	14.13	-23 0
2177	3	14 18	-21 2	2877.	3	14 47	-22.5	3387.	4	14 61	-21.7
2179	2	15 10	-20 8	2881.	3	14 37	-23.3	3388.	4	14.71	-21.0
2180	2	14 59	-23 7	2885	2	13 91	-22 7	3427.	2	14 67	-21.6
2183	2	14 08	-23 7	2886	2	14 81	-24 0	3429.	3	14.59	-21.6
2266	3	15 03	-20 8	2963	3	14 04	-21 9	3467.	2	14.35	-20 9
2267	3	14 84	-20 6	2997.	2	14 41	-23.9	3468.	3	14.12	-20.3
2273	4	14 04	-22 2	3056.	2	14 33	-20 0	3504.	2	13.94	-23.4
2274	3	14 78	-22 3	3058	3	13 78	-22 6	3517.	2	14 22	-21 0
2275	4	13 94	-20 2	3059	2	15 13	-23 5	3519.	3	14.01	-21.1
2303	4	14 44	-21 1	3062	4	14 89	-21.5	3520.	4	14.44	-20 4
2306	3	15 08	-24 3	3063	2	14.93	-24 5	3521.	4	14.08	-22 3
2314	4	14 28	-21 0	3064.	3	15.15	-21.9	3522.	2	13 94	-20 1
2317	3	15 00	-20.9	3066.	3	14 54	-22.7	3533.	2	14.79	-23.2
2330	2	14 72	-20 5	3072.	2	14 11	-24.5	3544	3	13.39	-20 3
2369	2	15 08	-20 8	3073.	2	15 23	-20.0	3545.	3	14.93	-21.9
2370	2	14 76	-20 0	3075.	2	14.72	-20.4	3548.	6	14.17	-20 5
2374	2	13 99	-23 1	3099.	3	14 50	-21 6	3549.	2	14.00	-20.3
2395	2	14 44	-23 8	3100.	3	14 24	-21.2	3555.	2	14.12	-20 2
2396	2	14 13	-23.1	3101	4	14 60	-21.5	3591.	2	13.48	-23.7
2407	2	14 19	-24 6	3103	3	14.55	-21.6	3627.	2	15 04	-21.6
2426	2	14 49	-22 9	3104.	3	13 86	-20 7	3628.	2	13 27	-24.7
2433	2	14 26	-21 1	3105.	2	14 22	-21.0	3649.	2	13 87	-22 2
2461	2	13 86	-22 4	3120.	2	15 06	-21.7	3733.	2	14 01	-21.4
2487	3	14 46	-24 1	3121	3	14 22	-22 4	3734.	5	14 29	-20 6
2488	2	13 44	-22 3	3150	2	14 31	-23.3	3749.	2	14 53	-21 1
2490	2	14 15	-20 5	3155.	2	13 99	-23.4	3754.	2	14.18	-24 2
2501	3	14 28	-24 2	3159.	2	13 37	-23 8	3773.	3	13.16	-22 9
2504	3	13 95	-21 5	3160.	2	12 85	-24.7				

TABLE II—*Continued*

Zone 25° to 30° { Mean Latitude = +27°01
Mean Diurnal Motion = 13°88

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
46	2	13°84	27°3	464	2	14°52	26°3	1271	2	13°95	25°0
54	2	14.73	26.0	509	2	14.20	25.9	1311	2	13.97	28.5
55	2	14.99	27.5	543	2	13.16	26.9	1363	2	13.44	25.0
64	2	13.88	25.2	614	2	12.87	27.8	1373	4	13.76	25.9
67	3	13.46	26.8	623	3	14.67	26.3	1385	1	13.66	28.4
77	5	13.48	28.5	647	4	13.34	27.0	1386	2	13.84	25.3
87	2	13.37	27.6	652	2	14.34	25.5	1418	3	14.45	25.3
91	2	12.50	26.9	654	2	13.84	29.4	1532	2	13.47	26.7
92	4	13.50	29.1	655	2	13.74	27.9	1605	3	14.01	25.0
93	4	13.70	28.4	656	2	14.53	28.6	1607	3	13.86	26.5
101	3	14.21	25.0	747	2	14.79	25.6	1639	3	13.71	26.2
103	3	13.94	27.3	748	2	12.38	30.0	1640	3	13.86	26.3
104	3	13.92	26.2	766	2	13.73	27.7	1684	3	14.09	25.0
126	3	13.74	27.6	769	2	14.13	25.2	1685	3	13.99	27.0
107	2	13.58	26.6	781	2	13.73	30.0	1687	3	13.48	27.5
123	2	13.58	25.5	795	4	14.32	25.7	1690	2	14.44	28.6
141	2	14.23	27.8	802	2	12.41	29.2	1691	3	14.14	25.3
142	3	14.24	27.3	803	2	14.05	25.0	1698	3	13.84	27.7
146	3	13.90	27.9	807	2	14.05	25.2	1759	2	14.59	27.2
147	3	14.79	26.5	841	4	13.98	26.3	1761	2	12.89	25.3
148	3	14.46	26.2	905	4	13.51	29.1	1826	2	14.14	27.1
159	3	14.06	25.6	907	4	13.79	27.4	1947	2	14.21	25.2
166	2	12.78	29.7	971	3	14.57	25.5	1973	2	13.33	26.0
23	2	14.33	26.7	975	2	13.65	28.4	1979	2	13.95	26.8
24	3	13.87	26.7	976	2	13.65	29.8	1980	2	14.05	27.6
199	2	13.96	26.4	1007	3	13.87	28.4	1988	2	13.64	25.5
200	2	13.83	25.0	1008	3	14.02	28.2	1989	2	14.97	27.0
205	2	14.08	26.7	1009	3	14.02	26.0	2000	2	13.49	28.0
206	2	13.83	26.5	1013	3	13.63	25.9	2001	3	13.77	29.6
247	2	13.57	29.7	1014	3	13.17	29.3	2008	2	13.30	28.3
279	2	13.87	27.5	1017	3	13.87	25.5	2012	6	13.01	29.7
324	2	14.30	26.6	1019	3	13.27	26.3	2016	5	13.37	29.3
329	4	13.97	26.2	1026	6	13.67	26.8	2046	2	13.96	29.6
342	2	14.03	29.0	1115	2	14.15	28.0	2062	4	14.39	27.0
349	2	14.13	26.8	1125	3	13.85	27.5	2124	3	14.45	25.2
379	2	14.22	27.2	1188	2	13.78	26.5	2175	2	13.47	30.0
426	2	13.40	26.9	1234	2	14.75	25.2	2299	4	13.73	29.4
438	2	14.40	25.2	1237	2	14.45	25.4	2572	2	13.72	25.0
451	4	14.90	27.2	1270	2	13.85	25.2				

TABLE II—*Continued*

Zone −27 to −30 | Mean Latitude = −27°28
| Mean Diurnal Motion = 14°05

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
51	2	14°48	−25°0	969	2	13°83	−25°8	1874	2	14°43	−28°3
73	3	14 62	−25 1	983	2	14.23	−26 5	1879	2	13.72	−25 5
80	3	13 77	−27 6	985	2	12.55	−26.3	1890	2	14.33	−27 4
81	2	14 38	−29 9	1106	3	13.59	−25.5	1896	2	13.89	−26.3
82	2	14.00	−28 9	1108	4	13.68	−27.3	1897	2	14.46	−27.5
111	2	14 66	−27 7	1110	2	13.95	−27.1	1898	2	14.17	−28.5
112	2	13 70	−27 2	1135	2	14.73	−28.0	1899	2	13.22	−27.3
115	2	14 63	−27 1	1156	2	14.63	−26.6	1931	2	14.31	−25 9
116	2	13 98	−29 2	1157	2	13.47	−25.2	1932	2	14.01	−27.0
127	2	14 42	−28 2	1180	2	14.52	−29.6	1933	2	12 31	−25.8
128	2	14 29	−31 0	1181	2	14.20	−27.9	1934	2	13.41	−29.8
130	2	14 87	−28 2	1184	2	14.94	−28.5	1937	2	13.81	−27.9
170	2	14 78	−28 6	1185	2	13.99	−28.3	1994	3	14.04	−27.0
181	2	14 85	−29 5	1192	3	14.10	−25 4	2181	2	13.47	−27.3
182	2	14 82	−28.1	1201	3	15.01	−25.8	2182	2	14.18	−29.8
1	2	14 90	−29 2	1203	3	14.76	−25.4	2185	2	13.37	−27.1
2	2	14 02	−27 3	1205	3	13.88	−26.3	2186	2	14.08	−27.3
3	2	14 70	−28 0	1265	4	14.24	−25.8	2304	3	15.28	−25.7
323	2	13 79	−26 0	1267	2	14.85	−25.7	2306	3	13.88	−29.5
352	2	14 44	−27.1	1275	2	14.25	−30 0	2307	3	13.98	−29 7
353	2	14.33	−27.7	1276	2	13.85	−28.2	2308	5	14.01	−29.3
391	2	14 02	−26 4	1279	2	14.65	−25.9	2310	3	13.93	−25.6
401	2	13 82	−28 9	1292	3	13.94	−25.5	2343	3	13.92	−27.1
405	3	13 82	−25 8	1293	3	13.44	−28 8	2377	2	14.76	−25.2
466	3	13 32	−26 6	1296	3	13.74	−26.1	2436	2	13.86	−28.6
467	2	14 65	−25 3	1297	2	14.27	−27.9	2499	6	14.07	−26.7
472	3	13 84	−25.3	1298	4	14.43	−26.8	2487′	2	13.38	−27.3
538	2	14 44	−25 2	1299	4	13.66	−28.0	2555	3	14.24	−26.2
559	2	14 44	−29 9	1430	2	14.10	−29 4	2621	2	15.19	−26.5
560	2	14.01	−26.1	1402	2	14.61	−25.8	2622	2	15.19	−27.3
567	2	14.55	−27 6	1405	2	14.61	−26.1	2644	6	13.96	−29.6
587	3	14 38	−30 0	1433	3	14.55	−25.3	2645	3	14.06	−28.0
595	2	13 82	−25 6	1468	2	13.81	−25.4	2646	3	14.34	−29 6
644	2	13 71	−27.9	1488	3	14.67	−26.4	2879	2	14.31	−26.4
645	2	13.93	−28 7	1492	3	14.04	−25.6	2880	2	15.21	−28.8
646	2	13.71	−29.5	1497	2	13.75	−27.2	2887	2	14.51	−29 7
647	2	14 02	−26 6	1498	3	13.89	−27.5	2937	2	14.00	−27.9
705	2	13 16	−27.1	1577	2	12.96	−29.5	3067	2	15.23	−26 1
717	2	13.74	−28.1	1579	5	13.24	−27.2	3076	2	13.19	−25.7
742	2	14 19	−27.3	1582	2	13.16	−28 0	3158	2	13.99	−25.5
750	3	14 44	−29.7	1585	3	12.94	−27.9	3163	2	14.20	−27.0
752	2	14 71	−28 0	1593	2	14 30	−26 2	3189	2	14.58	−27.8
753	2	14 19	−28 9	1594	2	14.11	−29.2	3190	5	13.94	−26.4
758	2	14 10	−26 6	1597	2	14.01	−25.2	3236	2	13.68	−29.0
810	2	12 92	−25.4	1656	2	14.03	−26.8	3242	2	13.55	−27.4
820	2	14 78	−29 6	1657	2	14.23	−30.0	3243	2	12.89	−26.1
823	2	14 61	−29 4	1705	2	14.13	−25.7	3360	2	14.48	−29 8
825	2	14 40	−27 6	1706	2	14 03	−29.7	3413	2	14.85	−25.1
845	2	13 91	−25 1	1726	2	13.55	−29 2	3523	2	14.22	−25.7
856	2	13 96	−26 0	1766	2	12.59	−25.5	3739	2	14.16	−26.9
883	3	14 29	−25 0	1798	2	13.81	−26 7	3740	2	14.44	−26.0
888	2	13 93	−28.1	1799	2	13.03	−27.1	3748	2	13.79	−27.8
890	2	14 63	−26 9	1847	2	12 62	−28.5				

TABLE II—*Continued*

Zone 30° to 35° { Mean Latitude = +32°.08
Mean Diurnal Motion = 13°.63

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
76	2	13°.24	32°.4	1117	2	14°.47	30°.5	1625	3	13°.46	34.2
94	4	13.80	30.3	1118	2	14.77	33.9	1688	3	14.09	30.2
95	4	14.16	32.3	1127	3	13.26	33.5	1689	2	13.72	30.7
102	3	14.48	31.7	1139	2	13.27	32.0	1724	2	13.95	32.1
105	3	14.53	30.8	1194	3	13.21	30.7	1725	2	13.95	34.9
106	3	14.16	34.6	1195	3	13.58	31.8	1825	2	13.43	32.0
257	3	12.83	30.5	1307	3	13.84	32.8	1948	2	13.51	30.7
259	2	13.66	34.1	1309	3	14.09	34.2	1999	3	13.37	31.0
617	2	14.57	33.5	1310	2	13.97	33.1	2002	2	13.96	33.3
657	2	13.94	30.1	1312	4	13.32	30.6	2016′	6	13.19	32.0
748	2	12.38	30.0	1313	4	13.05	32.7	2040	4	14.10	32.4
781	2	13.73	30.0	1317	4	13.17	31.8	2047	2	13.33	32.1
791	2	12.32	33.3	1339	2	11.98	32.5	2048	2	14.07	31.2
972	3	13.62	30.5	1553	3	12.80	30.5	2175	2	13.47	30.0
977	2	13.45	31.8	1554	2	13.56	33.8	2234	2	13.99	34.9
1021	3	13.87	30.3	1613	5	13.43	33.9	2301	2	13.84	31.2
1022	3	13.47	32.5	1614	3	13.10	30.9	2592	2	14.52	33.4
1083	2	13.16	35.2	1620	3	13.59	31.7	3209	2	13.18	32.0
1116	2	14.36	32.0	1621	3	13.94	31.4				

Zone −30° to −35° { Mean Latitude = −31°.98
Mean Diurnal Motion = 13°.88

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
113	2	14°.77	−31°.2	1183	2	14°.31	−32°.3	1846	2	14°.34	−31°.2
117	2	13.31	−33.5	1275	2	14.25	−30.0	1848	2	14.34	−32.0
128	3	13.26	−30.0	1277	2	14.25	−33.8	1935	2	13.21	−32.0
129	2	13.96	−31.5	1278	2	14.05	−33.0	1936	2	12.61	−33.2
183	2	13.41	−31.5	1304	2	13.97	−33.0	2184	2	13.67	−30.9
184	2	14.13	−30.6	1308	3	13.74	−30.8	2320	3	14.29	−30.3
220	2	14.94	−32.3	1352	2	13.45	−33.8	2342	2	13.76	−34.2
221	2	13.59	−30.8	1333	2	13.35	−31.0	2354	2	13.47	−31.0
405	2	13.22	−32.6	1571	2	13.76	−34.5	2355	2	14.58	−33.4
549	2	13.69	−30.5	1580	5	13.38	−33.3	2434	2	13.86	−30.8
550	2	13.69	−30.1	1581	3	13.73	−31.3	2435	2	14.16	−33.2
587	3	14.38	−30.0	1595	2	14.01	−30.8	2438	2	13.27	−34.4
592	4	13.16	−30.4	1657	2	14.23	−30.0	2618	2	14.55	−33.7
616	2	13.40	−32.7	1708	2	13.72	−31.2	2623	2	14.71	−31.8
937	2	12.83	−31.2	1711	3	13.94	−31.4	2624	2	14.71	−34.6
938	2	14.03	−30.5	1712	3	13.28	−32.7	2649	3	13.48	−32.2
1182	2	14.42	−32.0	1844	2	14.04	−34.5	3339	2	15.28	−30.1

Zone 35° to 40° { Mean Latitude = +37°.12
Mean Diurnal Motion = 13°.26

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
121	2	13°.18	36°.9	783	2	13°.93	38°.5	1827	2	13°.73	38°.4
122	2	13.71	35.4	840	2	13.54	35.2	2049	2	13.96	35.5
125	2	15.17	38.5	978	2	12.45	37.1	2050	2	11.87	35.1
258	2	9.89	38.8	1119	2	14.05	37.1	2051	2	14.07	37.5
475	3	13.55	36.0	1128	3	12.62	36.4	2235	2	14.09	38.6
480	2	12.74	38.8	1140	2	12.37	35.9	2593	2	14.21	38.0
519	2	13.57	36.9	1331	2	12.19	35.9				
782	2	13.53	37.7	1338	2	13.30	38.5				

TABLE II (Continued)

Zone [illegible] Mean Latitude = −37°.59
Mean Diurnal Motion = 13°.65

Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude
[illegible]	2	[illegible]	−38°.1	[illegible]	3	13°.12	−39°.9	2356	2	13°.78	−35°.6
[illegible]	2	14 .23	−39 .7	[illegible]	3	13.88	−35.1	2437.....	2	14.56	−36.1
[illegible]	2	[illegible]	−35 .4	1845.	2	13.13	−37.5	2439.....	2	13 .27	−35.3
[illegible]	2	14 .36	−36 .9	[illegible]	3	13 .63	−37.6	2440	2	13.67	−39 .6
[illegible]	3	12 .77	−39 .8	2327.	3	13.63	−37.2	2625.....	2	14.71	−38.9
1553.....	2	12 .05	−38 .2	2350.	2	13.47	−38.2				

Zone 40° to 45° { Mean Latitude = +41°.61
Mean Diurnal Motion = 12°.46

Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude
260.....	[illegible]	[illegible]	43°.4	1141.....	2	11°.47	40°.1	2053.....	2	13°.75	43 .3
[illegible]	[illegible]	[illegible]	40 .1	1514	2	12.88	40 .2	2054.....	2	12.18	40 .3
980.....	2	12 .85	40 .6	2052	2	13.12	44.9				

Zone [illegible] Mean Latitude = −41°.25
Mean Diurnal Motion = 12°.80

Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude
1700	3	[illegible]	−41°.5	2441.....	4	13°.59	−40°.8

Zone 45° to 50° Mean Latitude = +47°.73
Mean Diurnal Motion = 11°.58

Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude	Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude
[illegible]	2	[illegible]	50 .0	1315.....	2	11°.70	47°.5	1316	2	11°.89	45°.7

Zone [illegible] Mean Latitude = −[illegible]
Mean Diurnal Motion = [illegible]

Number	Days	Diurnal Motion Sidereal	Helio-graphic Latitude
[illegible]	2	[illegible]	[illegible]

TABLE II—*Continued*

Zone 50° to 55° { Mean Latitude = +51°.95; Mean Diurnal Motion = 11°.76

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude	Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
261.....	2	12°.38	53°.9	979.....	2	11°.14	50°.0

Zone −50° to −55° { Mean Latitude = −50°.8; Mean Diurnal Motion = 7°.87

Number	Days	Diurnal Motion Sidereal	Heliographic Latitude
754.....	2	7°.87	−50°.8

COLLECTED RESULTS AND THEIR REPRESENTATION BY FORMULAE

Various formulae have been used to represent the angular motion in different heliographic latitudes. Taking the values of the mean diurnal sidereal motions (ξ), for the different five-degree zones with the mean latitudes (ϕ), corresponding to these means, constants have been computed for the following formulae:

$$\xi = a + b \cos^2 \phi \qquad \text{and} \qquad \xi = c + d \cos \phi$$

with results as follows:

$$\xi = 11°.584 + 2°.976 \cos^2 \phi \qquad \text{and} \qquad \xi = 9°.174 + 5°.372 \cos \phi$$

In determining the mean latitudes and mean diurnal sidereal motions for substitution in the formulae for the derivation of the constants, the values for the two hemispheres have been combined, weighting them according to the number of points measured. Either formula represents the observations well within the error of measurement, as is shown in the following table.

TABLE III

REPRESENTATION OF THE OBSERVATIONS BY EMPIRICAL FORMULAE

Number of Points	ϕ	Observed ξ	$\xi = a + b \cos^2 \phi$		$\xi = c + d \cos \phi$	
			Computed ξ	$\Delta\xi$	Computed ξ	$\Delta\xi$
267.....	2°.78	14°.56	14°.553	+0°.01	14°.540	+0°.02
540.....	7.80	14.51	14.505	0.00	14.496	+0.01
842.....	12.56	14.38	14.419	−0.04	14.417	−0.04
1044.....	17.49	14.30	14.291	+0.01	14.298	0.00
664.....	22.20	14.12	14.135	−0.02	14.148	−0.03
274.....	27.17	13.98	13.939	+0.04	13.953	+0.03
107.....	32.03	13.75	13.723	+0.03	13.728	+0.02
39.....	37.32	13.43	13.466	−0.04	13.446	−0.02

Examination of the observations, however, shows that for every pair of zones except the first, 0° to 5°, the southern hemisphere has slightly higher angular motion. Therefore, using the $cos^2\ \phi$ formula, the constants were computed independently for the two hemispheres, as follows:

$$\text{Northern hemisphere, } \xi = 11^\circ.107 + 3^\circ.449 \cos^2 \phi$$

$$\text{Southern hemisphere, } \xi = 12^\circ.143 + 2^\circ.408 \cos^2 \phi$$

The representation of the observations by these formulae is given in Table IV.

TABLE IV

DISTRIBUTION OF THE OBSERVATIONS ON HEMISPHERES AND THEIR REPRESENTATION BY FORMULAE

Northern Hemisphere					Southern Hemisphere				
Number of Points	ϕ	Observed ξ	Computed ξ	$\Delta\xi$	Number of Points	ϕ	Observed ξ	Computed ξ	$\Delta\xi$
156.....	2°.88	14°.58	14°.547	+0°.03	111	− 2°.65	14°.53	14°.546	−0.02
323	7 .86	14 .51	14 .492	+0 .02	217.....	− 7.71	14.52	14.508	+0.01
499	12 .49	14 .33	14 .395	−0 .07	343.....	−12.67	14.43	14.435	+0.01
321.....	17 .39	14 .24	14.253	−0 .01	523	−17.58	14.35	14.331	+0 .02
311.....	22 .22	14.05	14 .063	−0 .01	353	−22.19	14.19	14.208	−0.02
116.....	27 .01	13.88	13.845	+0.03	158.....	−27.28	14.05	14.045	0.00
56	32 .08	13 .63	13 .585	+0.05	51	−31.98	13.88	13 .876	0.00
22	37 .12	13 .26	13 .300	−0.04	17.....	−37.58	13.65	13.655	−0.01

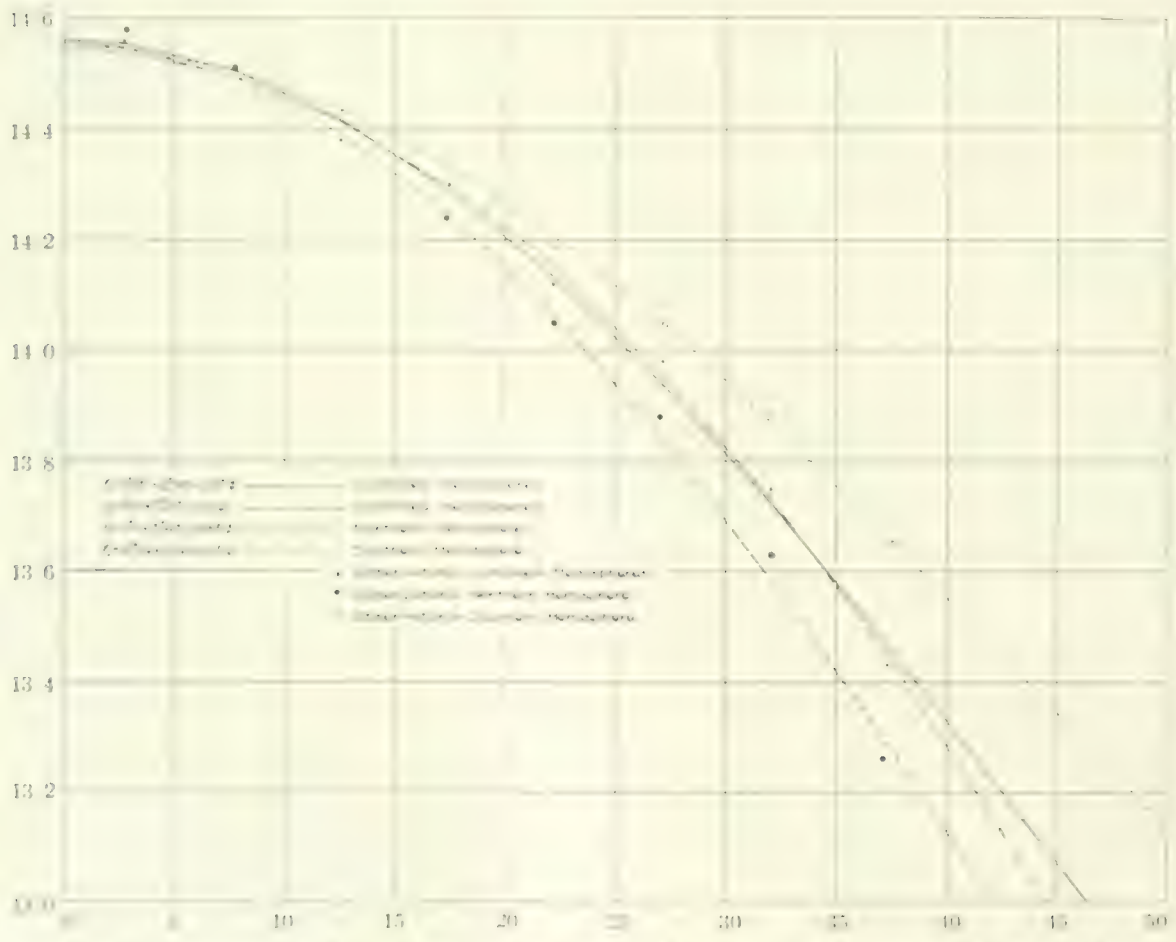


FIG. 1.—[illegible] of the observations of [illegible]. The [illegible] are [illegible] [illegible] the [illegible] [illegible].

The results of these computations for the combined and separate hemispheres are shown graphically in Figure 5. The asymmetry, with the zones of the southern hemisphere showing higher speeds than the respective zones of the northern hemisphere, while but slight, seems very consistent. It confirms, at least for the period 1903 to 1908, the first announcements of the 1911 observations by Hubrecht at the Cambridge Observatory.[7] The later discussion by Hubrecht of a more extensive series of plates, however, indicates that in June, 1911, the northern hemisphere had the higher angular speed.[8] Observations by De Lury and O'Connor[9] for certain dates in 1918 and 1919, in agreement with the present results, indicate higher velocities in the southern hemisphere. This is also indicated in observations on the faculae by Chevalier[10] in the years 1905 8.

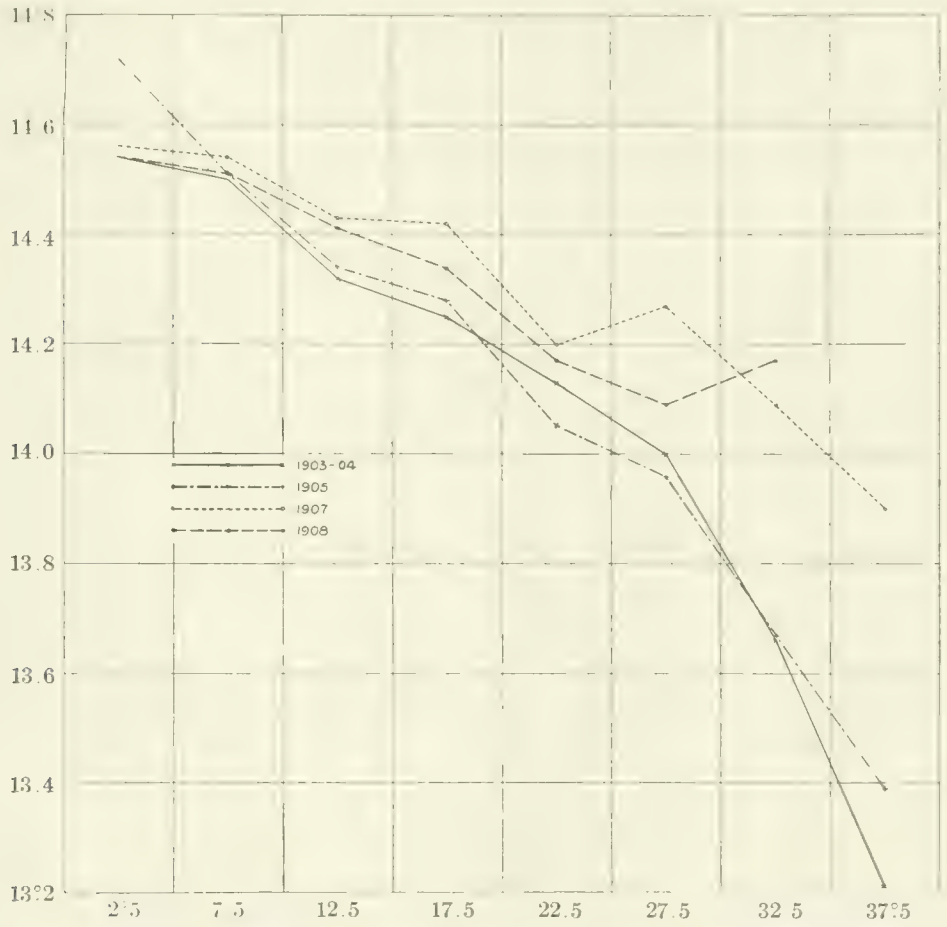


FIG. 6.—Comparison of observations of different years. The abscissae are heliographic latitudes, the ordinates are diurnal motions.

If curves should be drawn connecting the actual platted observations for each hemisphere separately and for the combined hemispheres, it would be seen that they would be sinusoidal about the mean curves derived from the formulae. While the deviations from the mean curve are small, the maxima and minima of these sinusoids fall in the same latitudes in the two hemispheres. This may present evidence bearing on the discontinuity surfaces called for by Emden's solar theory.[11] If the observations had been grouped in narrower zones the test of this would have been sharper.

[7] *Transactions of the International Union for Co-operation in Solar Research*, Vol. IV (1914), p. 120, and *M. N.*, Vol. LXXIII (1912), p. 24.

[8] *Annals of the Solar Physics Observatory*, Cambridge, Vol. III (1915), Part I, p. 60.

[9] *Publications American Astronomical Society*, Vol. III (1918), p. 88.

[10] *Annales de l'Observatoire Astronomique de Zó-sè, V* (1911), 85.

[11] R. Emden, *Gaskugeln;* Hubrecht, *Annals of the Solar Physics Observatory*, Cambridge, Vol. III (1915), Part I, p. 69.

CHANGE OF ROTATION PERIOD

Various investigators have discussed their observations with a view of detecting change in the rate of solar rotation. With a purpose to ascertain if the present series of observations shows such a change from year to year, the observations have been grouped into four periods: 1903–4, 1905, 1907, 1908, and separate means for the different zones have been derived. Means were also made for corresponding latitudes of the points and as these mean latitudes for given zones are not identical in the four groups, the angular velocities have been reduced to the center of the zone by applying a differential correction obtained from the general curve of the combined hemispheres. The comparison of these values is given in Table V and are platted in Figure 6. Certain slight differences are apparent: the angular velocities for 1907 and 1908 are higher than those for the earlier years. It might be remarked, also, that both 1907 and 1908 show between 20° and 30° an increase of angular velocity with the heliographic latitude, a characteristic in rotation curves which has been cited by Hubrecht. However, some of the points in these curves are determined by very few observations and unequally distributed in the two hemispheres, and therefore it would be injudicious

TABLE V

DIURNAL MOTIONS IN DIFFERENT YEARS

b	1903–4	1905	1907	1908	b	1903–4	1905	1907	1908
2°.5	14°.53	14°.72	14°.56	14°.54	22°.5	14°.13	14°.05	14°.20	14°.17
7.5	14.50	14.51	14.54	14.51	27.5	14.00	13.80	14.27	14.09
12.5	14.32	14.34	14.43	14.41	32.5	13.66	13.67	14.09	14.17
17.5	14.25	14.28	14.42	14.34	37.5	13.21	13.39	13.90	

to put too great reliance on their indications for a particular zone because the differences may be fortuitous. All four curves agree in showing positive deviations from smooth curves in latitude 17°.5. The curves were examined to see if there might be a progressive movement of these humps, perhaps following the zone of maximum spottedness. There is no indication that this is the case. Here again grouping in narrower zones might have been advantageous. The higher values for 1907 and 1908, compared with 1903–4 and 1905, seem consistent for all latitudes above 7°.5 and may represent a reality.

DIFFERENTIAL MOTION OF THE FLOCCULI

The methods of observation which are based on the measurement of positions of features on the solar disk have this advantage over the spectroscopic method, that they afford a possibility of grouping the features according to character and, in the case of faculae and flocculi, according to their location relative to the spots for the determination of the rotation periods in various classifications.

In this series of observations such groupings have been made with the view of detecting any systematic motions about the spots. First the test was made in two zones having large numbers of measured points: zones +10° to +15° and −15° to −20°. The points were grouped under the following classifications: (1) isolated flocculi; (2) flocculus groups; (3) according to the following position about uni-polar spots—preceding (*p*), poleward-preceding (*Pp*), poleward (*P*), poleward-following (*Pf*), following (*f*), equatorward-following (*Ef*), equatorward (*E*), equatorward-preceding (*Ep*). (4) according to these same positions about the nearest of bipolar spots, making three classes, namely, between (*b*), between-poleward (*bP*), and between-equatorward (*bE*), for those points midway between the members. The distance (*d*) of each flocculus from the spot with which it is associated, estimated in heliographic degrees,

By taking single zones there were too few points available in the many classifications for the derivation of trustworthy means. Each zone, however, showed that the flocculi unassociated with spots gave the same diurnal angular motion as the mean of all points and it is therefore warrantable to say that, while there may be systematic motions about the sun-spots, the spots do not drag their associated flocculi with speeds accelerated or retarded from the mean for all the measured points of the zone.

When it had been established that the velocity of the flocculi about spot groups in the average did not differ from the general average, it was justifiable to treat them separately. Neglecting then those flocculi not associated with spots, all others were grouped, irrespective of heliographic latitude, into the classifications about single and bi-polar spots, used above for the single zones. Naturally it was not permissible to use the diurnal motions directly because points of widely different latitude were grouped together and the means would not have been comparable. From the general curves of diurnal motions, Figure 5, the average diurnal motion (ξ) for any latitude could be taken directly. The diurnal motion of each flocculus entering into this discussion was compared with the value for its latitude taken from the curves and the differential motions ($\Delta\xi$) thus found, whether in excess (+) or defect (−), were recorded and combined to form the means in the different classifications, given in Tables VI to XII. It was found that more symmetrical representation could be obtained in the two hemispheres by using the general values of ξ from

TABLE VI*

Class	Number	$\Delta\xi$	d	$d\Delta\xi \sin a$	$[d\Delta\xi \sin a]$	Direction of Whirl
p	50	+0°041	3°8	0°000		
Pp	23	+0.155	3.4	+0.372	+0°642	
P	34	+0.056	3.0	+0.168		
Pf	53	+0.030	4.8	+0.102		+1°094 anti-cyclonic
f	71	−0.067	5.0	0.000		
Ef	49	−0.085	4.8	−0.288	−0.452	
E	31	−0.064	3.5	−0.224		
Ep	24	+0.020	4.2	+0.060		

* Summary of differential motions of the flocculi associated with single spots. Both hemispheres are combined but each ξ is referred to the ξ-curve of its own hemisphere to obtain its $\Delta\xi$.

the curves of the respective hemispheres. In every case therefore the values of $\Delta\xi$ entering in the tables just mentioned were obtained by subtracting from the individual diurnal motion the value for its heliographic latitude taken from the curve of its hemisphere. The values of $\Delta\xi$ about the spots, then, are not differential motions with respect to the spot in the sense of being referred to the motion of the spots, but are motions relative to means of diurnal motions of the flocculi. This practice of treating the flocculi about spots separately and referring them to the motion of the flocculi in general is further justified when it is found that for the 653 points considered the average $\Delta\xi$ has the small value −0°015.

The data are divided into two general groups, that for flocculi about single, uni-polar, spots and that for flocculi about bi-polar spots. Only the summaries are given in the tables. It is not thought necessary to give the individual results. The tables have quite similar form. In each is given the number of points in each classification (and in some cases they are too few to give reliable means considering the rather erratic individual results), the mean differential motion ($\Delta\xi$), and mean distance (d).

In Table VI is presented the summary for the combined hemispheres of the values of $\Delta\xi$ for all flocculi associated with single spots. The values of $\Delta\xi$ from this table with corresponding d are platted in Figure 7. A general rotary motion is indicated and its direction is opposite in sense to the rotation of the Sun on its axis and is therefore termed anti-cyclonic. If this is a true whirl the velocity for any classification would vary directly as the distance from the center of the vortex. It is sought to bring these results into form more directly comparable by deriving from the differential motions in heliographic longitude

the components tangential to the vortex and reduced to unit distance. These moments are given in the columns headed $d\Delta\xi \sin a$. The angle a is the angle measured from the parallel of latitude. It is of course recognized that for completeness the differential motions in heliographic latitude should have been derived and included in the discussion. $\Delta\xi \sin a$ is the projection of but one component of the differential motion. If the sum of the values of $d\Delta\xi \sin a$ on the equatorial side be subtracted from that on the poleward side the difference will be an indication of the degree of the whirl, the moment of the aggregated pair, and its sign will indicate the direction, according to conventions here used, cyclonic if negative and anti-cyclonic if positive. The figures in Table VI indicate *anti-cyclonic* motion unmistakably.

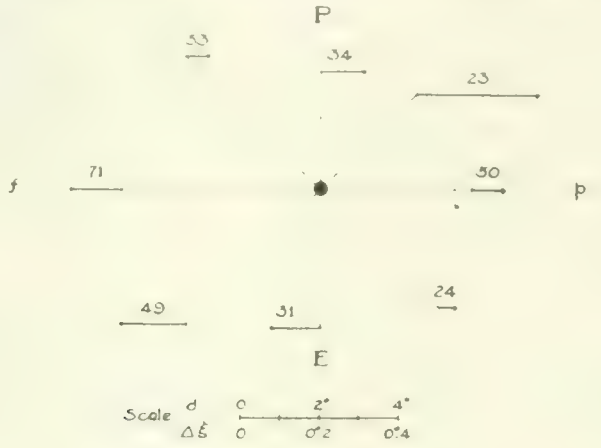


FIG. 7.—Differential motions in heliographic longitude about single spots. The mean distances of the points from the spots and amount of the motions are graphically represented. The numbers indicate the number of points from which the motions were derived.

TABLE VII*

Class	Northern Hemisphere						Southern Hemisphere					
	No.	$\Delta\xi$	r	$d\Delta\xi \sin a$	$\lvert d\Delta\xi \sin a \rvert$	Direction of Whirl	No.	$\Delta\xi$	r	$d\Delta\xi \sin a$	$\lvert d\Delta\xi \sin a \rvert$	Direction of Whirl
	29	−0°097	3°1	0°000			30	+0°134	4°3	0°000		
Fp	8	+0.086	2.7	+0.162	+0°125		15	+0.192	3.7	+0.500	+1°246	
P	19	+0.035	3.2	+0.112			15	+0.083	2.9	+0.241		
Ff	32	−0.045	4.7	−0.149		+0.297 anti-cyclonic	21	+0.146	4.9	+0.505		+1.403 anti-cyclonic
f	42	−0.151	3.3	0.000			29	+0.054	5.6	0.000		
Ef	38	−0.104	4.9	−0.360	−0.522		11	−0.021	4.3	−0.064	−0.157	
E	19	−0.084	3.3	−0.277			12	−0.033	3.7	−0.122		
Ep	9	+0.037	4.4	+0.115			15	+0.010	4.1	+0.029		

* Summary of differential motions of the flocculi about single spots, grouped according to hemisphere.

The question might be raised as to the suitability of combining values for the two hemispheres. The observations were thus combined to furnish more observations and provide more trustworthy means. In Table VII the observations are grouped according to hemisphere. The justification for the combination in Table VI is apparent, for the individual hemispheres reveal similar anti-cyclonic motions.

Groupings of points similar to those just considered for single spots are given for bi-polar spots in tables VIII and IX. The results for the combination of all observations, Table VIII, and Figure 8, show two things: first, that the flocculi about the two principal members of the bi-polar group are separating, those about the leader are forging ahead and those about the trailer are lagging behind, and second, that the motion about the leader is *cyclonic* and about the trailer, *anti-cyclonic*. When the observations are

separated in hemispheres, Table IX, the first fact is again envisaged and again for the leading spot the cyclonic motion is indicated, but for the southern solar hemisphere the sense of motion about the following spot does not agree with the combined result.

The observations at Mt. Wilson[12] on the magnetic polarity of sun-spots have indicated the existence of magnetic fields in sun-spots and, further, have indicated similar polarity for single spots and for the

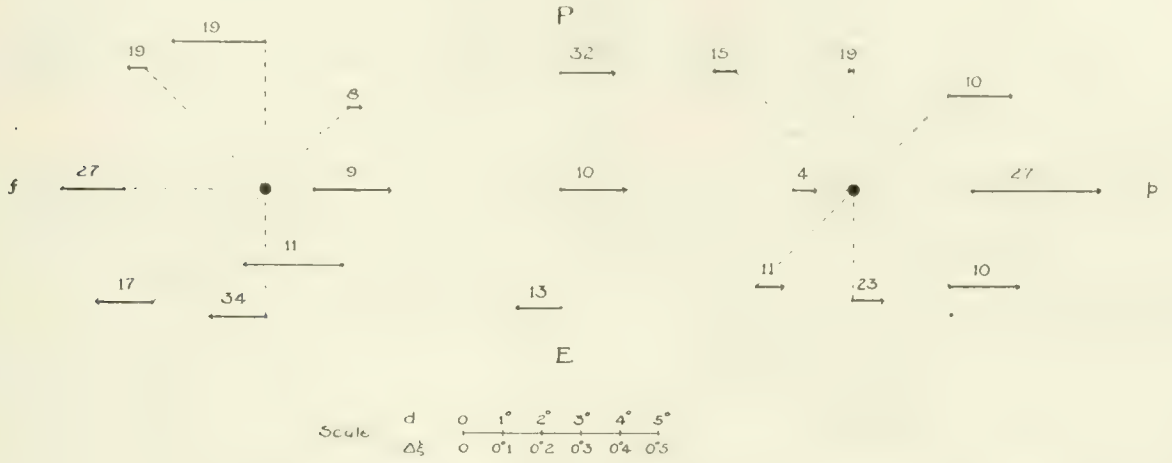


FIG. 8.—Differential motions in longitude about bi-polar spots. The numbers indicate the number of spots from which the mean distances (d) and mean motions ($\Delta\xi$) were derived.

TABLE VIII*

Class	Preceding Spot						Following Spot					
	No.	$\Delta\xi$	d	$d\Delta\xi \sin a$	$[d\Delta\xi \sin a]$	Direction of Whirl	No.	$\Delta\xi$	d	$d\Delta\xi \sin a$	$[d\Delta\xi \sin a]$	Direction of Whirl
p	27	+0°.332	3°.0	0°.000			9	+0°.191	1°.2	0°.000		
Pp	10	+0.166	3.4	+0.398	+0°.225		8	+0.030	3.0	+0.063	−1°.000	
P	19	−0.003	3.1	−0.009			19	−0.246	3.8	−0.936		
Pf	15	−0.054	4.3	−0.164			19	−0.041	4 4	−0.127		
f	4	+0.050	1.5	0.000		−0°.780 cyclonic	27	−0 164	3.6	0.000		+0°.360 anti-cyclonic
Ef	11	+0.152	3.5	+0.375	+1.005		17	−0.142	4.1	−0.411	−1.360	
E	23	+0.073	2.8	+0.205			34	−0.145	3.2	−0.464		
Ep	10	+0.174	3.5	+0.430			11	−0.255	2.7	−0.485		
	Between											
b	10	+0.162										
bP	32	+0.138										
bE	13	−0.114										

* Summary of differential motions of the flocculi about bi-polar spots. Combined hemispheres.

leading spot of bi-polar groups. If this magnetic field is explained by the supposition of a hydro-dynamical vortex, then the polarities observed would indicate rotation in the same direction for these types of spots if the electric charge carried by the material is of like sign. The indication of anti-cyclonic motion about single spots and cyclonic about the leader of bi-polar groups is then somewhat unexpected unless we had foreseen the likelihood of charges of unlike sign. If we accept the Mt. Wilson polarity observations and if the results of the present discussion showing opposite direction of whirl truly represent the motions in the

[12] *Contributions Mt. Wilson Observatory*, No. 165, 1919; *Astrophysical Journal*, Vol. XLIX (1919), p. 153.

vortices, then we must conclude that the predominant charges carried in the vortices of single spots and leaders of bi-polars are of opposite sign. This may have important bearing on the law of spot

TABLE IX*

Class	Northern Hemisphere						Southern Hemisphere					
	Preceding Spot						Preceding Spot					
	No.	$\Delta\xi$	d	$\Delta\xi \sin a$	$[\Delta\xi \sin a]$	Direction of Whirl	No.	$\Delta\xi$	d	$\Delta\xi \sin a$	$[\Delta\xi \sin a]$	Direction of Whirl
h	15	+0°414	2°9	0°000			12	+0°228	3°1	0°000		
Pf	7	+0 255	3.4	+0.610	+1.142		3	−0.043	3.3	−0.100	−1°006	
P	8	+0 268	3.1	+0.818			11	−0.199	3.1	−0.617		
Pf	6	+0 005	4.0	+0.014		−0°067 cyclonic	9	−0.093	4.4	−0.289		−1°297 cyclonic
f	1	+0.260	1.0	0.000			3	−0.020	1.7	0.000		
hf	4	+0.330	2.8	+0.650	+1.509		7	+0.050	4.0	+0.142	+0.291	
E	14	+0 091	2.9	+0.264			9	+0.045	2.8	+0.126		
hE	7	+0.234	3.6	+0.595			3	+0.010	3.3	+0.023		
	Following Spot						Following Spot					
h	5	+0 216	1.4	0 000			4	+0.160	1.0	0.000		
Pf	2	+0.245	2.5	+0.432	+0 470		6	−0.042	3.2	−0.095	−1.531	
P	6	+0.025	4.8	+0.120			13	−0 371	3.4	−1.260		
Pf	10	−0.026	4.5	−0 082		+2.033 anti-cyclonic	9	−0.058	4.3	−0.176		−0.703 cyclonic
f	12	−0 221	4.2	0 000			15	−0 114	3 2	0.000		
hf	6	−0.225	4.8	−0.760	−1.563		11	−0.097	3.7	−0.253	−0.728	
E	19	−0 035	3.2	−0.112			15	−0.285	3.3	−0.940		
hE	9	−0 362	2.7	−0.691			2	+0.220	3.0	+0.465		
	Between						Between					
h	5	+0.320					5	+0.004				
Pa	14	+0 078					18	+0.184				
hE	6	+0.073					7	−0.274				

* Summary of differential motions of the flocculi about bi-polar spots grouped according to hemisphere.

TABLE X*

Class	Heliographic Latitude ≥12°						Heliographic Latitude <12°					
	No.	$\Delta\xi$	d	$\Delta\xi \sin a$	$[\Delta\xi \sin a]$	Direction of Whirl	No.	$\Delta\xi$	d	$\Delta\xi \sin a$	$[\Delta\xi \sin a]$	Direction of Whirl
h	36	+0°061	3°5	0°000			14	−0°009	4°4	0°000		
Pf	11	+0 315	3 0	+0 666	+0°914		12	+0.007	3.7	+0.018	+0°389	
P	24	−0 021	3 1	−0 065			10	+0.242	2.9	+0.700		
Pf	35	+0 094	4.7	+0 313		+0 747 anti-cyclonic	18	−0.095	4.9	−0.329		+2°612 anti-cyclonic
f	47	−0 032	5 1	0 000			28	−0.120	5.0	0 000		
hf	28	−0 041	4.6	−0 133	−0 167		21	−0.145	4.9	−0.500	−2 223	
E	21	+0 016	3 4	+0 054			10	−0 232	3 6	−0 835		
hE	20	+0 088	4 2	+0 246			4	−0.298	4.2	−0 888		

* Summary of differential motions of the flocculi about bi-polar spots grouped according to latitude of the associated spots.

development. It must, however, be borne in mind that so far as the present observations are concerned we are dealing with average motions and, moreover, that we are dealing in motions at an average distance from the center of the spot of about $\frac{1}{3}$ while the spectroscopic observations are closer to the umbrae.

In the paper just cited it was also noted that during the progress of the sun-spot cycle the magnetic polarity of the spots reversed sign. The authors concluded that this change was probably not dependent on the latitude of the spots as earlier had been suggested[13] but dependent on the stage of the cycle. To test this, the points were again regrouped, putting those flocculi about spots with heliographic latitude greater than 12° in one group and those about spots closer to the equator in another. The dividing line of latitude 12° was chosen arbitrarily but gave roughly equal numbers of points on either side. For single spots, Table X, the anti-cyclonic character holds in both groups though it is much more pronounced in low latitudes. For the bi-polar spots, Table XI, the cyclonic sense for the leader and anti-cyclonic for the

TABLE XI*

Class	Heliographic Latitude > 12°						Heliographic Latitude < 12°					
	Preceding Spot						Preceding Spot					
	No.	$\Delta\xi$	d	$d\Delta\xi \sin a$	$[d\Delta\xi \sin a]$	Direction of Whirl	No.	$\Delta\xi$	d	$d\Delta\xi \sin a$	$[d\Delta\xi \sin a]$	Direction of Whirl
p	16	+0°.372	2°.8	0°.000			11	+0°.275	3°.3	0°.000		
Pp	6	+0.101	3.2	+0.228	−0°.103		4	+0.262	3.8	+0.640	+0°.804	
P	12	−0.105	3.1	−0.325			7	+0.173	3.1	+0.537		
Pf	9	−0.002	4.4	−0.006			6	−0.132	4.0	−0.373		
f	3	−0.020	1.7	0.000		−0°.341 cyclonic	1	+0.260	1.0	0.000		−0.727 cyclonic
Ef	4	−0.028	4.0	−0.079	+0.238		7	+0.254	3.3	+0.592	+1.531	
E	11	+0.049	2.5	+0.122			12	+0.095	3.1	+0.295		
Ep	7	+0.069	4.0	+0.195			3	+0.397	2.3	+0.644		
	Following Spot						Following Spot					
p	5	+0.350	1.2	0.000			4	−0.007	1.2	0.000		
Pp	5	+0.142	2.6	+0.260	−0.598		3	−0.157	3.7	−0.410	−1.518	
P	13	−0.295	3.2	−0.943			6	−0.140	5.3	−0.741		
Pf	9	+0.031	3.9	+0.085			10	−0.106	4.9	−0.367		
f	19	−0.123	3.3	0.000		+0.424 anti-cyclonic	8	−0.261	4.2	0.000		+0.013 anti-cyclonic
Ef	6	−0.033	3.5	−0.081	−1.022		11	−0.202	4.4	−0.626	−1.531	
E	23	−0.163	3.0	−0.489			11	−0.107	3.6	−0.385		
Ep	6	−0.278	2.3	−0.452			5	−0.230	3.2	−0.520		
	Between						Between					
b	4	+0.160					6	+0.163				
bP	19	+0.272					13	−0.058				
bE	7	−0.289					6	+0.090				

* Summary of diurnal motions of the flocculi about bi-polar spots, grouped according to latitude of the associated spots.

trailer is apparent in both groups, and just as the anti-cyclonic character is enhanced in low latitudes for single spots, so for the leader of the bi-polar the cyclonic character is emphasized. The increase in the factor of cyclonic indication, i.e., the moment of the pair, for the leader is accompanied by decrease of indication of anti-cyclonic sense of the following member. It would seem then that there is some connection between spot latitude and the character of motion.

The points about single spots were again regrouped, combining both hemispheres, but dividing them according to time. The observations of 1903–4–5 were in one group, those for 1907–8 in the other. The dividing line fell between flocculi Nos. 2212 and 2213. The results are given in Table XII. The indication

[13] *Contributions Mt. Wilson Observatory*, No. 10; *Astrophysical Journal*, Vol. XXV (1906), p. 61.

is almost identical with that from Table X in which latitude 12° was the dividing line irrespective of time. Anti-cyclonic motion is shown and is more pronounced for the later dates. Inasmuch as the zone of maximum spottedness drifts toward the equator during the progress of the cycle the majority of points for the earlier dates correspond with the majority for the group in latitude greater than 12°, and for the

TABLE XII*

Object	1905-06-07						1907-08					
	No.	ω	l	$\omega_0 \sin^2 \phi$	$\Delta(\omega \sin \phi)$	Direction of Whirl	No.	ω	d	$\omega_0 \sin^2 \phi$	$\Delta(\omega \sin \phi)$	Direction of Whirl
P_p	27	+0°826	4°0	0°000			27	+0°071	4°5	0°000		
P_f	5	+0.962	2.8	+0.798	+0°800		18	+0.087	3.6	+0.221	+0°764	
P	32	+0.821	4.0	−0.063			19	+0.117	3.1	+0.363		
Pf	32	+0.822	4.2	+0.065		+0°944 anti-cyclonic	18	+0.044	5.8	+0.180		+1°695 anti-cyclonic
f	24	−0.205	4.1	0.000			47	+0.003	5.5	0.000		
Ff	31	−0.132	4.8	−0.447	−0.144		18	−0.004	4.7	−0.013	−0.931	
E	17	+0.030	3.5	+0.140			14	−0.191	3.4	−0.650		
Ep	17	+0.059	3.9	+0.163			7	−0.076	5.0	−0.268		

* Summary of the corrections of the flocculi about single spots, grouped according to date.

later dates to fourth in the group of latitude less than 12°. In the two methods of separation there would be about the same amount of overlapping. There may be doubt as to the reality of the suggested modification of the rotation about the spots, but, even if real, it is impossible in these observations to discriminate between the rôles which simple distribution in latitude or stage in the sun-spot cycle play in bringing about the change.

COMPARISON WITH OTHER OBSERVERS

In comparing these observations with those of other observers the results of the combined hemispheres are used. Adams[14] and Kempf[15] have recently made comparisons of different determinations of the solar rotation and included the provisional results of this Rumford spectroheliographic determination. The present results should replace the values which they used. To the comparison made by Adams are added results from observations on sun-spots by Tisserand[16]; on the faculae by Chevalier[17]; on the calcium flocculi by Kempf[15]; and by the spectrographic method by Schlesinger[18]; by the Ottawa observers[19]—J. S. Plaskett, H. H. Plaskett, and DeLury; by Storey and Wilson[20]; by Evershed and Royds[21]; and by Hubrecht.[22] Though Hubrecht maintains[23] that it is impossible to apply Faye's law for a strict representation of the observations because he finds "large and comparatively persistent deviations from such

[illegible] No. 158, 1911, p. 118.

[illegible] No. 41, 1916, p. 36.

[illegible] 1913, p. 11.

[illegible]

[illegible]

* *Ibid.*, Vol. LXXIII, 1913, p. 564.

[illegible]

average laws," constants have been computed for the Faye formula, using the observations given in Table XXVI of his paper. The formulae used in determining the values given in Table XIII are as follows:

Dunér	$\xi = 10\ 60 + 4\ 21 \cos^2 \phi$
Halm	$\xi = 12\ 03 + 2\ 50 \cos^2 \phi$
Adams	$\xi = 11\ 04 + 3\ 50 \cos^2 \phi$
Schlesinger	$\xi = 10\ 77 + 3\ 4 \cos^2 \phi$
Ottawa Observers	$\xi = 10\ 53 + 3\ 71 \cos^2 \phi$
Storey and Wilson	$\xi = 11\ 55 + 3\ 2 \cos^2 \phi$
Hubrecht	$\xi = 10.19 + 3.02 \cos^2 \phi$
Adams $H\alpha$	$\xi = 13.6 + 1.4 \cos^2 \phi$
Adams λ 4227	$\xi = 12.5 + 2.4 \cos^2 \phi$
Carrington	$\xi = 14\ 42 - 2\ 75 \sin^2 \phi$
Spoerer	$\xi = 8.55 + 5.80 \cos \phi$
Tisserand	$\xi = 11.52 + 2.80 \cos^2 \phi$
Maunder	$\xi = 12\ 43 + 2\ 01 \cos^2 \phi$
Chevalier	$\xi = 12.20 + 2.67 \cos^2 \phi$
Kempf	$\xi = 12\ 37 + 2\ 06 \cos^2 \phi$
Fox	$\xi = 11.58 + 2.98 \cos^2 \phi$

A comparison of the present determination with the other values from the observations of calcium flocculi shows closer agreement with the first determination so made using the Kenwood spectroheliograms than with the later observations made at Mount Wilson and at Potsdam. The internal agreement of these four series of determinations is considerably closer than that among the spectroscopic observers.

TABLE XIII*

ϕ	Spectroscopic Observations										
	Dunér	Halm	Adams	Schlesinger	Ottawa Observers	Storey and Wilson	Hubrecht	Evershed and Royds	Mean	Adams Hα	Adams λ 4227
0°	14°81	14°53	14°54	14°17	14°24	14°75	13°21	13°77	14°25	15°00	14°90
5	14.78	14.50	14.51	14.14	14.21	14.73	13.19	.....	14.29	14.99	14.88
10	14.68	14.46	14.43	14.07	14.13	14.65	13.12	.....	14.22	14.96	14.83
15	14.53	14.37	14.31	13.94	13.99	14.54	13.01	.....	14.10	14.91	14.74
20	14.32	14.24	14.13	13.77	13.81	14.38	12.86	.....	13.93	14.84	14 62
25	14.06	14.09	13.91	13.56	13.58	14.18	12.67	.....	13.72	14.75	14.47
30	13.76	13.90	13.67	13.32	13.31	13.95	12.45	.....	13.48	14.65	14.30
35	13.42	13.70	13.39	13.05	13.02	13.70	12.21	.....	13.21	14.54	14.11
40	13.07	13.50	13.09	12.76	12.71	13.43	11.96	.....	12.93	14.42	13.91
45	12.70	13.28	12.79	12.47	12.38	13.15	11.70	.....	12.64	14.30	13.70

ϕ	Sun-Spots					Faculae			Calcium Flocculi				
	Carrington	Spoerer	Tisserand†	Maunder	Mean	Stratonoff	Chevalier	Mean	Hale and Fox	Hale	Kempf	Fox	Mean
0°	14°42	14°35	14°32	14°44	14°38	14°62	14°47	14°54	14°70	14°42	14°43	14°56	14°53
5	14.38	14.32	14.30	14.43	14.36	14.61	14 46	14.53	14.59	14.38	14.41	14.54	14.48
10	14.29	14.26	14.24	14.38	14.29	14.46	14.41	14.43	14.44	14.32	14.37	14.47	14.40
15	14.16	14.15	14.13	14.30	14.19	14.24	14.32	14.28	14.30	14.28	14.29	14.36	14.31
20	14.00	14.00	13.99	14.19	14.04	14.18	14.21	14.20	14.17	14.27	14.19	14.21	14.21
25	13.81	13 80	13.82	14.06	13.87	14.14	14.07	14.11	14.02	14.17	14.06	14.03	14.07
30	13.60	13 57	13 62	13.91	13.68	13.84	13 91	13.88	13.83	13.98	13.92	13.82	13.89
35	13.38	13.30	13.40	13.74	13.45	.....	.....	.....	.....	14.04	13 75	13.58	13.79
40	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.92	13.58	13.33	13.61
45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.40	13.07	13.23

* Comparison of results for solar rotation from various methods of observation.

† The observations by Tisserand were inadvertently omitted from the first draft of Table XIII, from which the figures were taken to prepare Fig. 9. Their inclusion lowered the mean values for the angular motion from sun-spot observations consistently by about 0°02; a quantity scarcely appreciable in the diagram.

The means from the determinations by the different methods are platted in Figure 9. The curves for the sun-spots, faculae, flocculi, and reversing layer are approximately parallel, but there are well-defined demarcations between them. The flocculi and faculae give velocities which are practically identical and

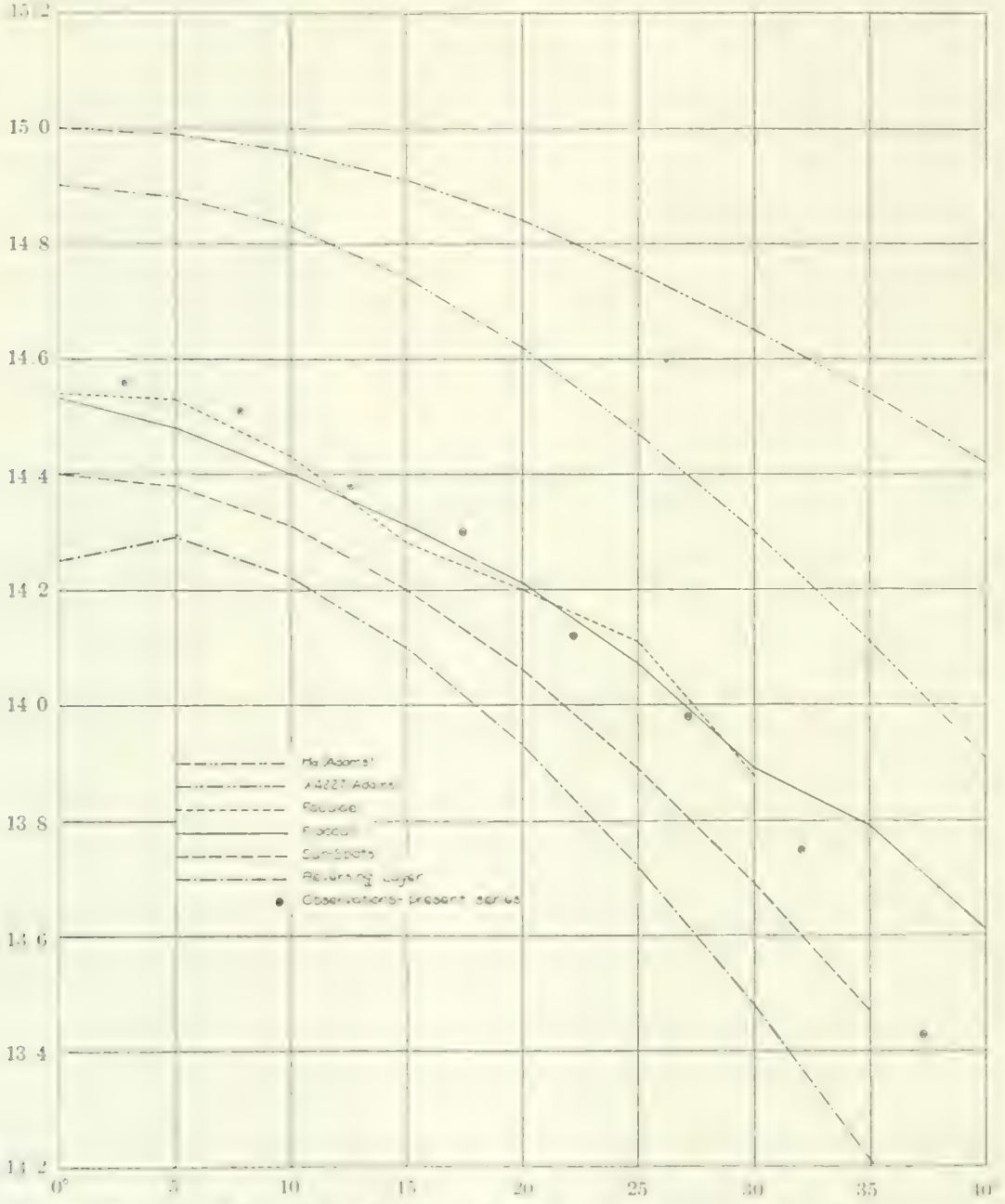


Fig. 9.—Comparison of the means of observations by the various observing methods. The abscissæ are heliographic latitudes, the ordinates are sidereal diurnal motions.

higher than those for the sun-spots and reversing layer. The reversing layer gives the lowest values, with the spots intermediate. Adams' spectroscopic observations for λ 4227 and *Ha* give velocities considerably higher. The velocities, then, derived by the different methods of observations show a regular progression which conforms with our idea of the succession of levels in the solar atmosphere in which the various types

of observations were made, the higher levels giving the more rapid motions. Adams states the relation in these words: "These results are all satisfied by a law of increase of angular velocity and decrease of equatorial acceleration with increasing altitude above the Sun's surface." As between the mean of the spectroscopic observations and the present series of observations on the flocculi the "decrease of equatorial acceleration" does not seem to hold. The reversing layer is the lowest stratum and shows lowest velocities. The faculae and flocculi are probably elevated high in the general stratum of the reversing layer, the spots being depressions in these elevated areas. The hydrogen which rises high in the solar atmosphere gives the highest velocities yet observed. Though we know that calcium rises high in the solar atmosphere and therefore the line λ 4227 should give, on this interpretation, high velocities, it is not clear why the velocities should be higher than those derived for the calcium flocculi. However, a similar discrepancy is found between the hydrogen flocculi, for which Hale finds the value, $\xi = 14^\circ.6$ at the equator, and the $H\alpha$ line, for which Adams finds $15^\circ.0$. It may of course be that the absorption producing the lines $H\alpha$ and λ 4227 at the limb takes place in a higher level than that in which lie the flocculi, or that the velocities of the flocculi are somewhat vestigial of the lower levels from which they sprang.

ADDENDUM I

AREAS OF THE FLOCCULI

An idea of the distribution of the flocculi can be deduced by estimating the area covered by flocculi in the different zones. In the method of measurement used in the solar rotation where the plates are projected on a globe with meridians and parallels ruled upon it, it is a fairly simple matter to determine the area of the flocculi by counting the square degrees covered by them. These counts were made in spherical quadrilaterals of ten degrees on a side. The measures were confined to an area within 40° of the central meridian and 50° of the equator. A sample of the record is given in the following table:

TABLE XIV

AREA COVERED BY FLOCCULI. SAMPLE RECORD OF ONE PLATE, NO. 580

Latitude	Longitude								Total in Zone
	East of Central Meridian				West of Central Meridian				
	−40° to −30°	−30° to −20°	−20° to −10°	−10° to 0°	0° to 10°	10° to 20°	20° to 30°	30° to 40°	
50° to 40° ...	1	4	4	3	4	2	4	5	27
40 to 30 ...	4	4	7	5	4	2	4	7	37
30 to 20 ...	9	11	14	11	10	12	10	10	87
20 to 10	2	4	5	4	40	41	6	6	108
10 to 0	4	3	2	3	4	5	4	5	30
0 to −10 ..	3	4	2	4	8	4	3	6	34
−10 to −20 ...	10	10	9	4	6	4	7	6	95
−20 to −30 ...	15	70	29	5	4	7	4	5	169
−30 to −40 ...	6	5	4	4	5	7	2	3	36
−40 to −50 ...	5	3	6	3	1	4	1	1	24

The estimates are necessarily very rough because the flocculi themselves vary in brightness and the density of the various plates is not uniform. But it is hoped that as the estimates were made by one observer they will be fairly consistent and show the latitudes of maximum flocculation with considerable accuracy. These counts were not made throughout the whole series but were discontinued for plates subsequent to June 8, 1905. Table XV gives a summary of the distribution for each plate, that is, the total square degrees in each zone for forty degrees of longitude on either side of the central meridian.

The sums at the foot of the table show the degree of flocculation according to latitude, with maxima in the two hemispheres in the neighborhood of 15°. The results in this table have been considered from two other points of view: first, to find if the degree of flocculation changed during the period involved; and second, to see if the zones of maximum flocculation shifted.

To accomplish the first of these objects the series was divided into three sections with an equal number of plates in each section, and the results shown in Table XVI and platted on the right side of Figure 10. It is at once apparent that the curves are quite similar in character and comparable in height, indicating no decided change of flocculation. This is of course also shown in the totals for the three series given in the table. No curve is drawn for the total flocculation of the whole series as its form can at once be seen as a summation of the three curves given.

TABLE XV

AREAS COVERED BY THE FLOCCULI

Plate Number	+50° to +40°	+40° to +30°	+30° to +20°	+20° to +10°	+10 to 0°	0° to −10°	−10° to −20°	−20° to −30°	−30 to −40	−40 to −50°
580	27	37	87	108	30	34	95	169	56	24
605	1	11	34	59	17	14	79	134	18	5
611	25	42	65	69	23	27	105	152	28	20
449	32	37	45	54	29	22	66	80	40	38
452	52	49	59	64	51	54	56	97	40	36
480	31	59	129	91	41	38	54	85	50	49
485	48	78	182	75	52	42	50	76	27	25
494	41	71	130	68	54	49	66	67	49	43
502	38	72	96	53	46	45	48	52	41	34
503	22	48	73	36	33	43	45	43	48	36
516	40	51	102	94	40	34	51	92	97	40
519	42	37	115	77	32	39	34	59	70	44
523	43	60	131	81	45	41	93	85	69	46
828	41	45	71	116	36	25	62	77	40	36
832	41	76	81	127	48	40	76	96	44	35
854	67	71	82	94	52	61	142	85	54	44
858	55	69	93	102	54	59	156	98	37	33
864	66	75	89	137	83	47	137	66	39	33
867	48	64	93	122	65	41	131	48	34	29
869	69	55	75	158	74	39	65	52	36	43
872	45	56	94	164	69	59	81	67	61	44
881	64	66	108	100	64	72	73	47	41	36
891	50	59	72	189	45	47	180	59	53	59
897	61	64	76	196	63	60	161	59	58	50
913	55	63	103	230	65	57	158	47	41	47
917	47	45	62	104	43	35	69	43	36	44
919	41	50	73	80	36	38	56	89	59	52
923	63	70	133	150	62	42	54	94	50	34
928	53	56	97	70	52	45	55	87	37	37
932	45	45	79	81	33	32	61	90	35	47
946	42	45	56	113	54	48	49	48	53	36
951	52	48	54	85	33	35	79	42	30	23
962	51	54	68	80	71	57	62	158	43	46
967	47	56	79	84	57	50	70	151	63	52
976	62	74	131	169	90	82	123	114	59	86
982	72	71	121	147	55	49	86	78	47	58
989	43	45	84	133	46	35	61	47	34	33
994	47	43	78	75	32	38	54	38	33	26
1004	44	58	80	79	49	46	49	41	46	35
1007	37	46	57	97	41	42	82	48	43	32
1017	43	49	53	158	40	35	103	63	40	53
1025	49	50	48	141	49	35	112	70	37	39
1030	59	67	66	151	63	51	147	72	49	65
1035	49	54	82	154	52	48	98	59	46	44
1051	37	48	63	48	34	39	77	93	33	32
1054	62	81	83	53	60	63	96	112	56	56
1068	59	62	57	114	36	35	46	48	50	57
1072	46	55	54	136	47	50	75	61	49	35
1075	41	49	51	157	46	36	85	64	37	31
1085	44	43	56	141	29	31	106	63	35	32
1089	41	49	73	114	56	46	164	77	40	30
1097	50	47	71	71	42	52	88	131	61	36
1108	43	44	46	50	34	44	60	83	35	37
1113	37	42	57	65	37	41	71	104	39	35
1118	46	42	91	70	34	43	42	49	37	29
1122	67	70	142	137	59	61	74	101	65	53
1130	56	68	147	154	59	64	94	128	66	51
1142	52	60	69	143	44	53	134	70	74	47
1147	51	54	67	116	51	43	110	53	74	56
1154	57	62	71	134	47	55	63	55	75	56
1160	51	55	130	71	48	53	60	68	62	43
1167	51	62	111	199	86	70	62	56	62	47
1173	55	56	92	199	74	61	132	84	56	43
1182	46	68	65	193	58	43	134	83	59	35
1187	58	60	81	152	67	56	147	74	38	51
1207	46	65	89	122	58	41	75	80	51	50
1218	63	90	106	154	76	60	116	151	73	60
1234	58	76	99	138	53	39	138	101	56	43

TABLE XV—*Continued*

Plate Number					10° to 0°	0° to −10°	−10° to −20°	−20° to −30°	−30° to −40°	−40° to −50°
1234	43	42	66	106	44	40	166	89	45	38
1[illegible]	51	56	[illegible]	94	59	62	145	107	52	38
1270	61	69	76	72	55	47	116	95	64	49
1294	55	116	72	78	74	56	115	70	82	59
1295	[illegible]	[illegible]	65	86	57	53	67	97	60	45
1301	45	67	[illegible]	86	70	59	85	105	64	49
1311	56	55	88	100	46	44	65	74	62	39
1314	[illegible]	71	108	111	70	72	84	78	59	39
1318	54	55	92	140	42	49	61	97	77	47
1324	[illegible]	[illegible]	114	109	72	69	114	136	57	37
1329	[illegible]	58	96	102	54	52	73	124	39	35
1[illegible]	71	91	76	105	79	58	75	75	68	41
1344	[illegible]	88	74	130	90	48	63	73	53	37
1348	72	88	69	141	76	61	74	63	56	32
1354	58	69	61	164	85	60	65	75	63	48
1362	41	56	110	119	53	43	170	96	47	42
1366	49	63	119	132	76	49	153	79	56	44
1370	44	53	102	92	46	34	114	69	49	33
1[illegible]	[illegible]	47	74	65	45	51	119	75	47	31
1[illegible]	[illegible]	[illegible]	65	89	49	[illegible]	54	59	50	37
1394	51	49	77	80	57	53	70	121	51	39
1404	68	71	86	127	69	44	64	58	45	27
1408	50	53	61	129	53	37	48	45	43	38
1561	45	[illegible]	55	80	51	42	146	92	56	41
1565	33	48	55	90	82	46	142	96	57	47
1[illegible]	35	44	72	170	105	38	133	96	49	44
1[illegible]	[illegible]	[illegible]	77	239	42	28	64	63	37	20
1[illegible]	30	32	74	219	48	39	68	67	44	24
1429	42	77	144	201	42	33	85	70	35	22
1432	[illegible]	62	129	166	35	29	68	45	32	25
1438	[illegible]	50	120	77	39	34	54	31	31	26
1443	[illegible]	45	66	81	42	27	54	[illegible]	32	33
1450	41	37	48	66	34	32	87	49	30	28
1453	41	32	55	57	37	30	103	47	44	33
1467	[illegible]	42	103	172	52	54	81	53	38	25
1470	32	54	119	181	94	53	88	50	35	28
1476	27	31	120	162	91	35	57	41	33	29
1516	37	42	112	109	61	41	102	47	34	35
1519	42	50	69	101	59	41	94	80	33	33
1529	28	31	41	46	87	37	156	52	26	28
1535	61	61	69	80	60	49	244	122	71	48
1543	[illegible]	35	65	237	133	39	46	39	46	30
1546	[illegible]	63	89	271	145	47	41	43	48	31
1588	50	41	55	51	45	43	135	95	46	36
1590	42	[illegible]	52	42	35	36	80	74	33	30
1601	30	42	55	176	48	25	47	38	29	24
1603	48	58	95	183	84	41	51	57	39	39
1626	[illegible]	40	53	85	71	31	40	38	35	34
1630	29	36	66	39	29	24	32	26	25	23
1634	38	45	74	45	39	35	46	37	30	34
1640	42	54	92	90	76	42	50	42	33	42
1644	34	54	78	132	55	29	44	38	24	39
1648	[illegible]	[illegible]	50	102	39	34	37	27	21	21
1656	45	53	49	116	54	33	50	44	28	36
1662	[illegible]	56	57	128	56	80	54	44	33	37
Total	[illegible]	[illegible]	10096	14203	6795	5524	10722	9154	5730	4765

TABLE XVI

NUMBER OF ANGLES OF DISTRIBUTION IN THREE GROUPS WITH EQUAL NUMBERS OF PLATES IN EACH

	Number of Plates	+30° to +90°	+20° to +30°	+10° to +20°	0° to +10°	−10° to −20°	−20° to −30°	−30° to −40°	−40° to −50°	Total for Series
I	13	[illegible]	2270	3590	4569	2005	1798	3877	3223	1839	1623	25990
II	13	[illegible]	2631	3354	5001	2372	2143	3974	3548	2516	1826	29388
III	40	1559	1934	3152	[illegible]	2418	1583	3371	2383	1575	1316	24124
Total	466	5678	[illegible]	10096	14203	[illegible]	5524	10722	9154	5730	4765	79502

I—Plates 49, Aug. 6, '03, to Plate 1017, June 18, '04

II—[illegible] to Plate 1164, Feb. 26, '05

III—Plate [illegible], June 1, '05, to Plate 1625, June 5, '06

For the second study the plates were divided into three series covering equal intervals of time. This gave quite different numbers of plates in the three groups, as is seen in Table XVII. These results have been platted on the left side of Figure 10, where the maxima of the curves are indicated. It will be seen

TABLE XVII

SUMMARY OF AREAS OF FLOCCULATION, GROUPED ACCORDING TO DATES

Series	No of Plates	+50° to +40°	+40° to +30°	+30° to +20°	+20° to +10°	+10° to 0°	0° to −10°	−10° to −20°	−20° to −30°	−30° to −40°	−40° to −50°	Total by Series
I.....	13	445	652	1248	929	493	482	842	1191	613	440	7335
II.....	69	3674	4249	5696	8441	3884	3459	6509	5580	3542	3009	48043
III.....	40	1559	1934	3152	4833	2418	1583	3371	2383	1575	1316	24124
Total..	122	5678	6835	10096	14203	6795	5524	10722	9154	5730	4765	79502

I = Plate 449, Aug. 6, '03, to Plate 611, Oct. 11, '03
II = Plate 828, Mar. 7, '04, to Plate 1354, Oct. 29, '04
III = Plate 1362, Nov. 1, '04, to Plate 1662, June 8, '05

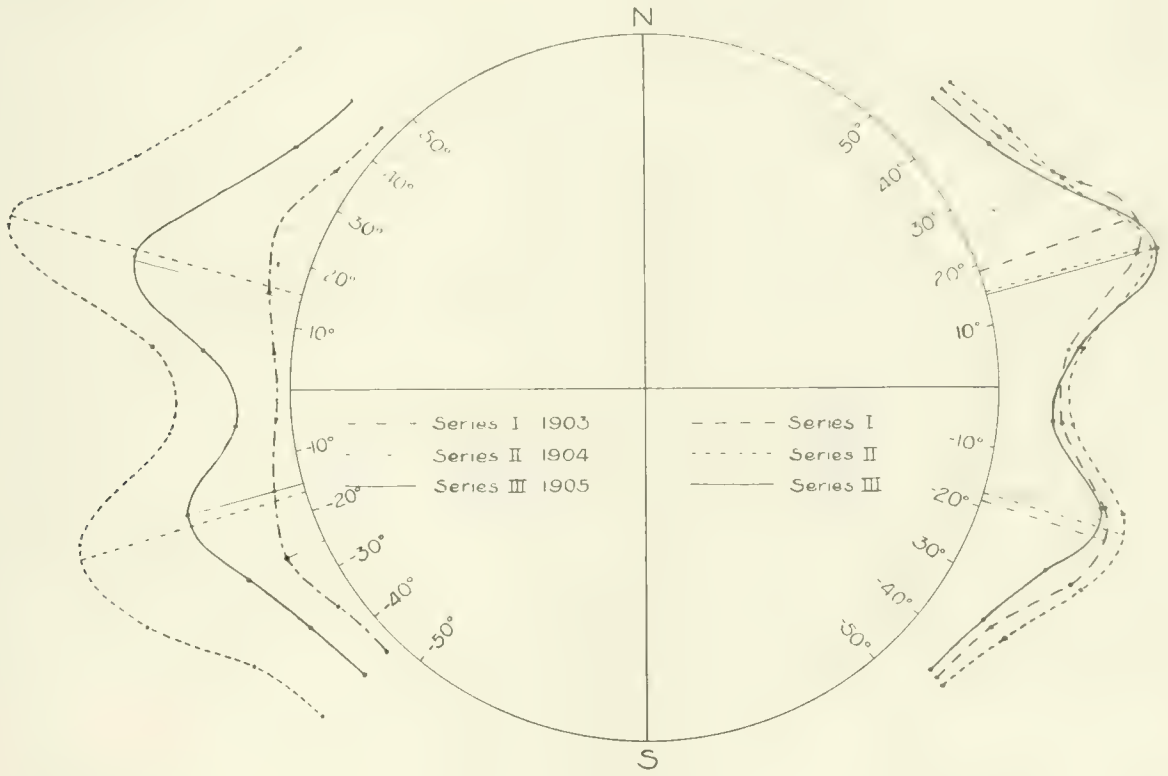


FIG. 10.—Relative areas covered by the flocculi. On the left the observations are grouped by dates to detect movement of the zone of maximum flocculation. On the right they are grouped in series with equal numbers of plates to compare the amounts of flocculation during the period.

that the maxima shift toward the equator during the period between 1903 and 1905. This shift is also shown in the curves at the right of the table. This result was of course to have been expected as the progressive movement of the spots toward the equator during the progress of a sun-spot cycle was long ago recognized. The large areas of flocculi are either associated with the spots or are found in the latitude of maximum spottedness.

ADDENDUM II

POSITIONS OF SUN-SPOTS

The measurement of the Rumford spectroheliograms included the determination of the positions of the sun-spots. In general their positions were not measured at distances greater than 50° from the central meridian. It is understood, of course, that the sun-spot positions were measured on the globe in the same method as the flocculi, but the heliographic longitude of the central meridian has been added so that the spot positions are referred to the same meridian as are the Greenwich positions.

The spot positions have not been discussed for a determination of the rotation period because they were too few in number and therefore it was considered unwarranted in view of the far richer material collected at Greenwich. It is thought, however, desirable that these positions should be published and they are here collected in Table XVIII. The spots of this series are designated alphabetically. So far as has been possible an identification has been made with the Greenwich numbers, and the Greenwich positions are added for comparison.

In discussing the comparison of the spot positions taken from the spectroheliograms and from the Greenwich photoheliograms, it must be borne in mind that the observations were not simultaneous and that in many cases the spots on the spectroheliograms are partially covered or bridged by overhanging flocculi. In a considerable number of cases several nuclei have been measured which on a direct photograph might have appeared as a single spot. In complex groups, such as Greenwich 5473 of March 5, 1905, it is quite impossible to identify the individual nuclei because they are rapidly changing. In some such cases it is the custom at Greenwich to give but a single position for the center of the group rather than to record the positions of individual nuclei. With these cautions in mind, it will be seen that the agreement is quite satisfactory between the two series.

A check on the consistency of the observations was made by taking at random one hundred spots which had been measured at the two stations and determining the extreme differences of measured position on the same spot both in longitude and latitude in the two series and totaling them without regard to sign. The spectroheliograms give $[\Delta\lambda] = 95°.6$, $[\Delta\phi] = 55°.4$. For Greenwich the corresponding quantities are $[\Delta\lambda] = 125°.5$, $[\Delta\phi] = 60°.5$. These quantities are of the same order of magnitude. Changes in measured position which enter into these summations are of course partly real and partly due to error of measurement. Whichever of these causes prevails, the check demonstrates that the two series are affected to about a like degree. The globe machine, then, makes no sacrifice in accuracy and offers the advantage of very marked saving of time and labor in the derivation of positions of spots.

TABLE XVIII

COMPARISON OF SUN-SPOT POSITIONS WITH GREENWICH PHOTOHELIOGRAPHIC RESULTS

PLATE NUMBER AND DATE	LETTER	GREENWICH NUMBER	SPECTROHELIOGRAPH		GREENWICH	
			Longitude	Latitude	Longitude	Latitude
449 Aug. 6, '03 1^h50^m	o'	5068	308°.4	−21°.8	306°.4	−22°.7
	o''		308.6	−22.3		
452 Aug. 7, '03 8^h39^m	o	5068a	309.1	−22.4	307.9	−22.0
480 Aug. 17, '03 3^h10^m	p	5072	237.0	20.5	235.9	20.5
	q	5072	238.2	20.2	237.2	20.3
	r	5072	239.5	19.9	238.9	20.0
	s		204.5	−18.5		
485 Aug. 18, '03 10^h08^m	p	5072	237.2	20.8	236.8	20.5
	q	5072	238.2	20.3	237.7	20.1
	q'	5072	229.7	22.4	229.3	21.9
494 Aug. 19, '03 3^h38^m	q	5072	237.1	21.0	237.2	20.7
503 Aug. 21, '03 10^h05^m	t	5077	103.4	25.1	102.5	25.6
516 Sept. 10, '03 4^h20^m	u	5083a	193.1	−18.0	192.5	−18.1
519 Sept. 11, '03 10^h38^m	u	5083a	192.4	−18.8	192.2	−18.1
523 Sept. 12, '03 10^h00^m	u	5083a	194.0	−18.3	192.3	−17.6
580 Oct. 9, '03 8^h22^m	a	5091a	245.5	12.9	245.3	13.0
	b	5092a	214.7	−22.0	214.1	−21.7
	c	5094	284.7	−21.0	285.0	−21.5
	d		208.9	−23.1		
	e	5093	206.5	−22.5	205.5	−21.2
	f		206.2	−21.0		
	k		210.0	−21.2		
	g	5093	200.2	−18.3	200.2	−18.7
	h	5093	197.8	−19.8	197.1	−19.5
	i	5093	197.8	−21.3	197.0	−21.4
	j	5093	197.7	−22.3	197.7	−23.2
	l	5093	200.2	−20.8	199.7	−20.8
605 Oct. 10, '03 10^h59^m	a	5091a	245.3	12.8	245.2	12.9
	b	5092a	214.5	−21.9	214.6	−21.7
	c''	5093	207.8	−21.5	206.0	−21.1
	g	5093	200.2	−18.3	199.7	−18.0
	i	5093	197.6	−21.1	197.7	−21.0
	l	.....	200.3	−21.0	.....	.....
	m	5093	201.2	−19.7	200.5	−20.0
611 Oct. 11, '03 1^h17^m	a	5091a	245.3	13.1	244.9	12.8
	b	5092a	214.2	−22.0	214.0	−22.2
	k'		209.8	−20.6		.....
	e'	5093	206.1	−21.5	206.0	−21.2
	g	5093	199.6	−18.1	199.8	−18.4
	h		196.8	−19.4		
	i	5093	197.5	−20.5	196.9	−21.1
	j		196.9	−21.6		
	l	5093	199.9	−20.3	200.6	−20.7

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Star Number	Spectrophotograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
828			24°2	−18°6	No photograph	
842	*x*	5176	24.1	−18.6	23°9	−18°4
Mar. 8, '04	*y*	5179*b*	67.3	17.1	67.1	16.5
854						
Apr. 12, '04		5202*a*	278.9	−14 8	278.8	−14.3
		5202*b*	271.4	−18.1	271.7	−18.0
	z	5202	274.5	−18 9	274.2	−18.6
		5204*a*	244.4	6 0	244.1	6.5
858	*x*	5202*a*	278.9	−15 0	278.8	−14.3
Apr. 13, '04	*y*	5202*b*	271.3	17 9	272.5	−17.7
			274.8	−18 6		
	z'	5202	273.2	17.9	274.9	−16.7
	z''		273.3	−18 8		
		5204*a*	244.3	6 0	244.4	6.7
864			279 1	−14 8		
Apr. 14, '04	*x'*	5202*a*	279.9	−13 3	278.7	−14.6
	x''		279.2	−13 3		
	y	5202*b*	271 0	−17 8	272.9	−17.4
	y'		272.6	−18 1		
		5202	275.1	−18.5	273.8	−19.8
	z'		274.0	−18 7		
		5204*a*	244.5	6.0	244.6	6 5
867		5202*a*	280.1	−14 3	279.7	−14.7
Apr. 16, '04	*y*	5202*b*	271.1	−17 2	271.7	−17.2
			272.8	−16.6		
			275.9	−18.1		
		5204*a*	245.1	6 5	245.2	6.6
	ab	5206*a*	197.8	17.0	197.5	18.0
			280.7	−16.3		
869	*y*	5202*b*	270.7	−17.0	272.4	−17.4
Apr. 18, '04		5204*a*	246.0	6.9	245.5	6.5
	ab	5206*a*	197.6	18.1	197.4	18.1
872		5204*a*	246.0	7.0	246.0	6.7
Apr. 19, '04	*ab*	5206*a*	197.4	18 2	197.5	18.1
876		5206*a*	197 1	18.6	197.1	18.4
Apr. 20, '04						
881	*ab*	5206*a*	196.9	18 9	196 9	18 8
Apr. 21, '04		5208	200.7	8 4	199.5	8 4
		5208	197.4	8.7	194.7	8.2
891		5210*a*	111 4	12.6	110.8	12 6
Apr. 26, '04		5209*a*	105 7	13 0	104 9	13.1
			107 0	14.1		
		5210	105 9	14.3	105 5	13 3
			104 7	13 3		
			104 2	12.4		
		5210	99 3	15 0	100 1	14 4
			100 9	15 9		
897		5210	111 4	12 3	111.1	12 0
Apr. 27, '04		5209	105 9	13 2	105 4	13 1
		5210	107 4	14.0	107 1	13 6
		5210	99 6	15 4	98 9	14.8
			99 1	14 8		

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
906 Apr. 28, '04 11^h34^m	*ag*	5209*a*	107°.1 104.8	−13°.2 −12.9	105°.4	−13°.0
	af	5210*a*	111.0 109.8	12.6 12.9	111.2	12.3
	ah	5210	107.5	14.0	107.7	13.8
	ai	5210	98.8	15.0	99.1	14.7
913 Apr. 29, '04 11^h51^m	*ag*	5209*a*	107.4 105.0	−13.6 −12.9	105.6	−13.1
	af	5210*a*	109.8	12.8	111.0	11.6
	an	5214	60.1	17.8	59.4	18.7
917 Apr. 30, '04 11^h13^m	*ag*	5209*a*	107.5 105.2	−13.0 −12.6	105.7	−13.0
	af	5210*a*	110.0	13.0	110.5	12.7
	an	5214	59.9	17.5	58.5	18.3
	ao	5213*a*	9.0	−22.3	8.1	−21.5
919 May 2, '04 2^h26^m	*an*	5214	58.1	18.2	58.8	18.0
	ao	5213*a*	8.7	−21.9	8.0	−21.7
	ap	.....	14.1	24.7	.....	.....
	aq	5215	10.7 9.9	22.7 22.9	11.8	23.8
923 May 3, '04 9^h22^m	*ao*	5213*a*	8.4	−21.8	7.9	−21.3
	ap	5215	15.3	24.6	14.4	24.3
	aq	5215	9.7	23.1	10.3	23.2
928 May 4, '04 9^h12^m	*ao*	5213*a*	5.9	−21.6	7.9	−21.3
	ao'	5218	357.8	−20.0	358.2	−19.8
	ap	5215	15.6	24.9	13.8	23.7
	aq	5215	9.6	23.0	9.9	23.0
		5215	10.9	23.2	11.1	23.2
932 May 5, '04 9^h37^m	*ao'*	5218*a*	1.3	−19.7	359.9	−19.6
	aq	5215	9.9	24.9	10.2	23.7
	ar	5217	323.6	18.2	321.7	18.7
	as	5217	317.3 317.2	18.8 18.2	316.7	18.9
946 May 20, '04 11^h13^m	*at*	5232*a*	193.6	17.5	193.4	17.5
	au	.....	98.1	12.9	.....	.....
951 May 21, '04 9^h52^m	*at*	5232*a*	193.5	17.8	192.4	17.8
	au	5235	98.7	13.5	97.9	13.3
	au'	5235	101.6	12.2	99.6	12.4
962 May 31, '04 11^h56^m	*av*	5240	7.8	−21.9	7.4	−21.1
967 June 1, '04 10^h21^m	*av*	5240	7.4	−21.8	5.3	−21.9
972 June 8, '04 11^h14^m	*aw*	5246	277.4	18.7	277.1	19.0
976 June 9, '04 9^h47^m	*aw*	5246	277.4	18.4	274.3	18.9
982 June 10, '04 10^h57^m	*aw*	5246	277.8	19.2	277.0	18.5
	ax	5250	228.8	18.9	229.0	19.3
	ay	5251*a*	185.2	11.8	184.7	12.1

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroscopic Grade		Greenwich	
			Longitude	Latitude	Longitude	Latitude
989	*ax*	5246	278°.2	18°.8	277°.5	18.8
June 11, '04	*az*	5250	228.6	18.9	229.4	20.1
8^h46^m	*aa*	5251*a*	184.7	12.0	184.4	12.6
994			227.2	19.6		
June 13, '04	*ax*	5250	227.4	18.6	227.8	19.0
10^h07^m			227.8	18.0		
			226.8	21.1		
	aa	5251*a*	185.9	12.2	185.5	12.6
	az'	5250	233.0	20.1	231.5	19.7
	az''		231.9	20.5		
1004	*ax'*	5250	225.8	21.1	226.4	21.0
June 14, '04			226.8	19.2		
10^h30^m	*ax*	5250	227.1	18.3	228.1	18.6
			227.8	17.8		
	aa	5251*a*	186.5	12.2	185.7	12.7
	aa'		187.0	13.2		
	az	5250	232.7	20.1	232.1	20.1
	ba	5250	222.9	23.1	222.4	23.5
1007	*bb*	5253*a*	121.5	12.4	120.6	12.8
June 16, '04	*bb'*		119.5	11.5		
9^h41^m	*bc*	5253	113.4	13.0	113.2	14.3
	bd	5252*a*	122.8	−17.4	122.4	−16.9
	be	5252	120.4	−16.9	120.0	−16.3
	bf	5254*a*	110.5	−22.0	109.7	−22.5
1013	*bb*	5253*a*	120.7	12.0	120.8	12.8
June 17, '04	*bd*	5252*a*	122.8	−17.5	121.6	−16.5
10^h54^m	*be*		121.6	−17.2		
	bf	5254*a*	109.9	−22.7	109.5	−21.7
1017	*bb*	5253*a*	120.3	12.2	120.2	12.9
June 18, '04	*bd*	5252*a*	122.6	−16.8	120.9	−16.8
9^h18^m	*be*		121.9	−16.3		
	bf	5254*a*	109.1	−22.4	108.8	−22.3
1025	*bb*	5253*a*	120.0	12.0	119.6	12.1
June 20, '04	*bg*	5256	52.1	19.0	50.5	19.5
10^h10^m						
1030	*bb*	5253*a*	119.8	12.0	119.4	12.7
June 21, '04	*bg*	5256	52.7	19.4	51.4	17.7
10^h00^m						
1035	*bb*	5253*a*	119.7	11.9	119.4	11.9
June 22, '04	*bg*	5256*a*	53.0	19.4	51.9	19.8
9^h56^m			51.8	19.5		
	bh	5256*b*	47.8	18.6	46.8	19.0
	bi		46.4	18.2		
	bj	5252	115.4	−15.1	115.3	−15.2
	bk	5256	42.5	19.0	41.9	19.4
1039	*bb*	5253*a*	119.7	12.5	119.3	12.0
June 23, '04			118.9	11.5		
0^h00^m.5	*bg*	5256*a*	52.4	19.8	51.7	19.8
			50.5	19.5		
	bh	5256*b*	47.0	18.7	46.9	18.9
	bi		46.0	18.6		
	bj	5252	117.0	−15.1	115.2	−15.9
			115.1	−15.0		
	bl	5252	122.9	−14.5	122.7	−14.8
1051	*bm*	5250	316.9	−19.4	315.8	−18.9
June 24, '04	*bn*	5250	307.4	−18.9	308.3	−19.2
9^h21^m	*bo*	5261	328.9	−22.6	329.9	−22.4
	bp	5262	262.5	14.7	260.5	15.4

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
1054	*bm*	5259*b*	316.7	−19.5	316.4	−19.5
July 2, '04	*bp*	5262*a*	263.0	15.2	261.2	15.3
9^h12^m	*bp′*		261.9	15.0		
	bq	5261	333.6	−22.9	332.8	−22.0
1068	*br*	5264*a*	149.9	12.9	150.6	13.2
July 12, '04	*bs*	5264*b*	140.1	12.5	140.1	12.7
9^h54^m	*bt*		138.9	11.8		
	bu	5264	140.3	15.2	141.0	15.7
1072	*br*	5264*a*	150.1	13.0	149.8	13.0
July 13, '04	*bs*	5264*b*	140.0	12.9	141.6	13.2
9^h21^m	*bt*		139.1	11.9		
	bu	5264	140.3	16.1	140.2	16.2
1075	*br*	5264*a*	150.6	12.2	150.3	12.7
July 15, '04	*bs*	5264*b*	139.6	12.3	139.2	12.7
8^h48^m	*bt*		139.3	11.7		
	bu′	5268*a*	117.8	−13.0	118.2	−12.5
	bv	5266	109.2	13.8	107.9	13.3
	bw		107.1	11.5		
	bx	5267	180.1	16.3	180.5	16.5
	by	5267	183.6	16.1	183.6	16.2
1085	*br*	5264*a*	151.0	12.9	150.8	12.6
July 16, '04	*bs*	5264*b*	139.6	13.2	140.1	12.5
10^h20^m	*bt*		139.4	12.3		
	bu′	5268*a*	118.1	−12.4	118.2	−12.5
	bv	5266	109.0	14.9	108.8	16.6
	bw	5266	107.0	12.5	108.2	13.4
1089	*br*	5264*a*	152.7	13.0	151.6	12.4
July 18, '04	*bs*	5264*b*	139.7	13.5	140.5	12.7
9^h12^m	*bt*					
	bu′	5268*a*	117.7	−11.4	117.8	−11.2
	bw	5266	107.2	12.5	107.6	12.5
	bz		61.4	−19.4		
	bz′	5269*a*	59.9	−18.4	59.9	−19.0
	bz″		58.6	−18.8		
1097	*bw*	5266	107.5	11.9	107.3	11.8
July 20, '04	*bz*	5269*a*	61.2	−19.4	60.8	−19.1
9^h01^m	*ca*	5269	48.4	−22.3	48.5	−21.9
	cb		46.9	−22.2		
1103	*bz*	5269*a*	61.4	−19.0	60.9	−19.0
July 21, '04	*ch*	5272	63.9	13.8	62.7	13.8
8^h58^m						
1108	*bz*	5269*a*	61.1	−19.0	60.8	−18.9
July 22, '04	*ch*	5272	64.7	13.4	63.9	13.4
8^h14^m						
1113	*bz*	5269*a*	60.9	−18.5	60.6	−18.7
July 23, '04	*cc*	5277	4.7	−20.0	3.5	−19.0
10^h37^m	*cd*	5277	1.3	−21.2	0.8	−20.7
	ce	5273*a*	342.2	20.7	341.9	21.1
	ch	5272	66.1	12.9	65.0	12.9
1118	*bz*	5269*a*	60.4	−18.8	59.6	−18.1
July 25, '04	*cc*	5277	4.5	−20.4	5.2	−19.5
9^h49^m	*cf*	5273*b*	324.6	20.8	325.1	20.7
	cg	5275	320.8	24.6	320.6	24.5
1122	*ci*	5278*a*	307.3	14.2	305.9	14.9
July 27, '04	*ci′*	5280	298.7	9.4	299.7	10.2
8^h15^m	*cj*	5278*b*	298.5	14.1	297.8	14.6

TABLE XVIII—*Continued*

Plate Numbers and Date	Letter	Greenwich Number	Star Heliocentric		Greenwich	
			Longitude	Latitude	Longitude	Latitude
1130 July 28, '04 8h18m	*cn*	5278*a*	308°.9	14°.1	308°.5	14°.5
	cj	5278*b*	298.3	14.0	298.2	14.4
1142 Aug. 1, '04 8h32m.5	*ck*	5281	{300.9	−17.3}	294.5	−17.5
	cl		{299.5	−17.2}		
1147 Aug. 2, '04 8h34m	*ck*	5281	{300.6	−17.2}	295.0	−17.6
	cl		{299.7	−17.1}		
1154 Aug. 3, '04 8h30m	*ck*	5281	299.2	17.0	299.0	−17.1
1160 Aug. 6, '04 9h32m	*cm*	5282	{257.2	10.6}	259.5	11.0
	cn		{261.5	11.8}		
	co	5283*a*	182.6	25.9	181.7	26.1
	cp	5285*a*	157.0	12.7	156.4	12.7
1167 Aug. 8, '04 9h17m.5	*co*	5283*a*	181.5	26.1	181.4	26.2
	cp	5285*a*	156.4	12.9	156.2	13.1
1173 Aug. 11, '04 8h45m.5	*co*	5283*a*	180.1	26.0	179.5	26.1
	cp	5285*a*	{156.9	13.9}	155.4	13.4
	cp'		{155.2	13.5}		
	cq	5286*a*	110.5	13.4	108.0	13.3
	cr	5289	128.1	15.1	127.4	15.4
	cs	5289	125.4	16.6	124.8	16.6
1182 Aug. 12, '04 8h41m	*co*	5283*a*	180.0	26.5	179.7	26.2
	cp	5285*a*	155.1	13.5	155.8	13.7
	cq	5286*a*	110.3	−13.4	109.8	−12.7
	cs	5289	124.9	15.2	124.7	16.8
	ct	5290	{164.9	11.1}	162.9	11.7
	cu		{162.6	11.9}		
1187 Aug. 14, '04 9h17m	*cq*	5286*a*	110.7	−13.3	109.9	−13.0
			109.3	−13.3		
	cp	5285*a*	155.1	13.4	156.6	13.3
	ct	5290	165.9	11.2	165.2	11.1
	cv	5294*a*	59.0	18.5	58.8	−18.2
1207 Aug. 23, '04 8h59m	*cw*	5295*a*	318.7	13.4	318.0	13.3
1218 Aug. 24, '04 8h16m.5	*cw*	5295*a*	318.5	13.2	318.2	13.5
	cy	5296	275.9	−18.2	279.7	−18.6
	cy'	5296	273.1	18.3	272.9	−18.0
1234 Aug. 25, '04 8h41m	*cw*	5295*a*	318.5	13.5	318.5	13.6
	cx	5299	{279.8	19.3}	278.9	18.8
			{279.3	18.8}		
	cy	5296	275.8	−19.8	278.9	−18.3
	cz	5298*a*	256.3	−14.4	256.1	−14.1
1243 Aug. 26, '04 8h42m	*cw*	5295*a*	318.7	13.5		
	cx	5299	280.8	19.3	280.1	19.3
	cy	5296	277.0	−19.6	276.4	−19.4
			276.0	−19.4		
	cz	5298*a*	256.5	−14.6	256.6	−14.4
1255 Sept. 9, '04 10h0m	*dd*	5310	122.2	−18.2	124.6	−16.5

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
1270 Sept. 10, '04 9^h27^m	*da*	5307	121°3	−18.8	124.0	−16°5
1294 Sept. 29, '04 11^h26^m5	*dc* *de*	5316*a* 5319*a*	245.1 161.2	31 1 −22 1	244.5 161.0	30.9 −21.5
1295 Oct. 1, '04 9^h12^m5	*dc* *dd* *de* *df* *dg*	5316 5316 5319*a* 5318 5320	244.1 235.6 162.0 160.6 241.0 108.3	31.5 32.5 −22.0 −21.5 −12.5 23.1	243.9 235 9 160.7 242.6 107.5	31.0 31.7 −21.2 −13.7 23.6
1311 Oct. 6, '04 9^h39^m	*dh* *di* *dj* *dk* *dl*	5326*a* 5321 5321 5320 5320*a*	133.3 129.0 125.5 107.1 101.4	16.8 19.5 19 5 23.2 23.3	132.6 128.5 126.1 106 6 101.2	16.6 19.0 19.7 23.1 23.7
1314 Oct. 7, '04 9^h33^m	*dh* *dj* *dk* *dl* *dm* *dn* *do*	5321*a* 5321 5320 5320*a* 5323 5322 5322	134.4 125.0 107.3 100 8 100.8 101.0 53.4 54.4 45.7	16 3 19.2 23.0 24.7 23.6 22.9 11.8 −17.5 −18.7	133.3 125.0 107.4 101.6 50.1 51.5 45.3	16.6 19 5 23.8 24.2 12.5 −17.0 −18.0
1318 Oct. 15, '04 9^h22^m	*dm′* *dn* *dp*	5325*a* 5322*a* 5329*a*	23.6 25.0 57.6 320.9	13.0 12.1 −16.8 −23.7	23.4 57.4 320.9	13.3 −16.5 −22.5
1324 Oct. 17, '04 9^h46^m	*dm′* *dp*	5325 5329*a*	23.9 320.5	13.4 −23.4	23.7 319.9	13.2 −23.3
1329 Oct. 18, '04 9^h50^m	*dp* *dq*	5329*a* 5332*a*	320.2 265.5	−23.7 13.8	319.7 263.9	−23.5 14.1
1336 Oct. 26, '04 9^h41^m	*dr* *ds* *dt* *du* *du′*	5338 5338 5339 5336 5336	232.6 228.8 219.6 203.0 209.8	13 7 14 3 10 8 9.4 9.5	231.8 228.6 217.5 201.9 207.2	13.6 13.7 10.9 9.9 9.4
1344 Oct. 27, '04 9^h55^m	*dr* *ds* *dt* *dv*	5338 5338 5339 5339	233.1 228.4 219.2 213.9	12 9 14 1 11.0 10 1	232.2 228.6 216.3 213.0	13.4 14.2 11.2 11.3
1348 Oct. 28, '04 9^h44^m	*dy* *dr* *dt* *dv* *du* *dw* *dx*	5343 5338 5339 5336 5336 5342	128.7 230.2 233.1 219.2 214.7 213.1 215.0 198.9 198.7 204.1 202.9 142.7	−17.0 12 8 13.3 11.5 10 5 11.5 13 1 9.9 9 2 9 9 9 8 14.8	128.8 232.1 215.8 204.4 202.7 141.9	−16.5 13.3 11.5 9.6 9.7 14.7

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectrophotograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
1354	*dr*	5338	232°6	13°0	232°1	12°8
Oct. 29, '04	*ds*		218.8	11 5		
9h50m			212.9	11 3	216.1	11.7
	dt	5339	214.2	10 7		
			215 2	12 8		
	du	5336	203 9	9 3	203 8	9.9
			202.3	9 7		
	dv	5336	210.2	10 1	208 7	9.6
	dy		129 5	−17 1		
	dz		119.3	−18 2		
			128.2	−16 0		
	ea	5343	126.3	−15 9	123.6	−16 5
			124.5	−16 2		
	eb		123.4	−16 0		
1362	*dy*	5343*a*	129 9	−16 9	129.0	−16 8
Nov. 1, '04	*dz*	5343	120 0	−17 9	119.5	−17.9
10h00m						
1366	*dy*	5343*a*	130.1	−17 4	129.5	−16 8
Nov. 2, '04	*dz*	5343	122.7	−17 9	119.8	−17.5
9h55m						
1370			130 8	−17.7		
Nov. 3, '04	*dy*	5343*a*	129 5	−17.4	129.7	−16.9
9h25m	*ec*	5351*a*	60 2	−16.6	60.1	−16.3
1380			131 0	−17.7		
Nov. 4, '04	*dy*	5343*a*	129.8	−17.5	130.2	−16.8
9h43m	*ec*	5351*a*	60.3	−16.5	60 2	−16.3
1391	*ed*	5356*a*	301.2	−22.5	299.6	−22.0
Nov. 12, '04						
11h11m						
1394	*ed*	5356*a*	301.3	−22.6	300 4	−22.3
Nov. 14, '04						
10h01m						
1404	*ef*	5360*a*	219.5	10.0	218.8	10 3
Nov. 22, '04	*eg*	5366	245.9	27.6	244.6	28 2
9h43m						
1408	*ef*	5360*a*	219.3	10.3	219.0	10.4
Nov. 23, '04	*eg*	5366	245 6	26 9	245.7	27.2
11h20m	*eh*	5366	244 9	29 7	244.9	29.4
1419	*el*	5381*a*	351.0	20 7	351.0	21.2
Dec. 13, '04	*em*	5383	333.0	16 9	335.1	16 6
10h24m	*en*	5380*a*	292.1	12 8	290.4	12 8
	eo		290.7	12 8		
	ep	5390	269.7	17 8	268.8	17.3
	eq		272 1	15 5		
	er		270 5	15 3		
	es	5390	239.0	16 0	238 2	−16 3
	et	5391	265.2	23 2	264 3	23 2
	eu	5396*a*	240 0	28 5	240 3	28 9
1424	*el*	5381*a*	351 1	20 5	350 8	20 9
Dec. 14, '04	*em*	5383	333 0	16 8	333 2	16 3
10h41m5	*en*	5380*a*	292 0	12 6	290 8	13 0
	eo		290 5	12 8		
	ep	5390	268 8	17 7	269 9	17 6
	eq		272 3	15 4		
	es	5390	239 2	16 3	238 6	−16 0
	et	5391	264 4	23 5	264 0	23 3

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
1429 Dec. 15, '04 11^h04^m	*em*	5383	332°7	16°8	332°7	17°4
	en		292.3	12 2		
	eo	5389*a*	289.9	12 8	290.4	12 5
	ep		290.7	11 0		
	ex		291.4	12 5		
	eq	5390	268.7	17 9	268.1	18.0
	es	5399*a*	240.0	−16 3	238.6	−16.8
	et	5391	263 8	24 0	262.8	23.5
	eu	5396*a*	239.7	28 7	239.7	29.1
	ew	5390	240.9	28 5	269.4	15.4
			267.5	14 9		
1432 Dec. 17, '04 11^h15^m	*en*		292.0	11 8		
	eo		288.7	12.4		
	ep		268.4	17.2		
	ew		266.7	14 3	No photograph	
	ey		210.0	12 0		
	ez		237.3	26 7		
1438 Dec. 19, '04 11^h18^m5	*eq*	5390	267.6	17 9	267.7	17 8
	eq	5400*b*	209.1	12 7	208.4	12.6
	fa	5390	268.0	14 3	266.8	15.2
1443 Dec. 21, '04 11^h41^m5	*fb*	5402	245.1	−16.3	243.4	−15.7
1450 Dec. 30, '04 10^h42^m5	*fc*					
	fd	5413	76.4	−15.9	75 2	−14.8
	fe		75.4	−14.3		
	ff	5413	70.6	−16.0	72.7	−16.1
			71 5	−16.7		
1453 Dec. 31, '04 10^h51^m	*fc*					
	fd	5413*a*	77.0	−15.5	76.4	−14.9
	fe					
	ff	5413*b*	70.3	−16.0	70.7	−15.6
1467 Jan. 12, '05 11^h39^m5	*fg*	5417	278.8	11.7	278.2	12.0
	fh	5420*a*	263.2	17.3	263.2	17.6
	fi	5421*a*	255.0	20.7	255.0	20.8
	fj	5416	330.2	−16.8	329.0	−16.2
	fk	5424*a*	230.6	9.6	230.5	9.5
	fl	5424*c*	219.2	9.5	219.3	9.2
	fm	5424*b*	223.8	9.3	224.9	10.0
	fn	5425	242.6	19.4	241.9	19.4
1470 Jan. 13, '05 10^h54^m	*fg*	5417	279.3	12.4	278.5	12.1
	fh	5420*a*	263.6	17.4	263.2	17.7
	fi	5421*a*	255.2	20.9	255.0	20.8
	fk	5424*a*	231.1	9.3	230.7	9.3
	fl	5424*c*	219.5	9.5	219.1	9.7
	fm	5424*b*	224 7	9.2	223.7	9.4
	fn	5425	244.3	20.0	243.8	19.6
1476 Jan. 14, '05 10^h51^m	*fg*	5417	279.2	11.9	278.6	12.1
	fh	5420*a*	263.6	17.2	263.0	17.5
	fi	5421*a*	255.2	20.8	254.6	20.9
	fk	5424*a*	230.9	9.0	230.5	8.9
	fl	5424*c*	219.0	9.9	218.6	9.8
	fm	5424*b*	223.4	9.1	223.4	9.4
	fn	5425	245.5	20.2	244.8	20.0
	fp	5424	224.8	8.3	224.9	8.1
1516 Feb. 17, '05 10^h51^m5	*gf*	5455	196 8	19 9	196.3	19.3
	gc	5466	112.2	−22.9	110.8	−22.2
	gd		111.7	−22.0		
	gc	5467*a*	102.2	18.8	101.3	17.5
	gb	5465	167.8	10.4	167.7	10.2
	ga	5452*a*	200.8	20.9	200.8	21.1

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
1519 Feb. 18, '05 10^{h}54^{m}	*gt* *gq*	5469*a* 5466	76°.7 104.7	−15°.6 −21.7	77°.4 105.8	−14°.9 −22.4
1529 Feb. 28, '05 10^{h}17^{m}.5	*gs* *gv* *go* *gm* *gt* *gk* *gq* *gp* *gm* *gj* *gi*	5471*a* 5471 5470*b* 5470	335.3 331.9 329.4 328.0 328.0 333.2 326.5 325.7 324.7 34.6 40.1	−17.3 −17.5 −17.6 −19.7 −17.2 −18.2 −16.3 −15.8 −17.2 6.7 6.0	330.7 324.8 33.8 39.3	−17.4 −16.3 6.5 6.6
1535 Mar. 1, '05 11^{h}02^{m}.5	*gt* *go* *gv* *gl* *gp* *gq* *gm* *gk* *gi*	5471 5471 5471*a* 5470*a*	329.6 329.4 327.9 327.6 325.2 324.5 333.1 39.9	−16.8 −18.0 −19.7 −17.1 −16.0 −16.9 −17.9 5.9	324.6 330.7 39.9	−16.3 −17.2 6.6
1543 Mar. 8, '05 11^{h}19^{m}	*hf* *hc* *hd* *hc* *hb* *ha* *gz* *gy* *gx* *gw* *gv* *gu*	5473 5473 5473 5477*a* 5473 5473 5473*a* 5473 5471*c*	277.1 278.1 272.4 271.2 303.0 279.3 272.1 263.8 265.4 268.1 278.5 324.2	13.1 13.1 9.3 9.5 17.5 7.4 7.2 10.9 10.7 12.2 9.7 −15.6	279.0 303.0 278.2 270.4 277.9 324.1	11.9 18.1 8.2 10.2 10.6 −14.8
1546 Mar. 9, '05 11^{h}05^{m}	*hi* *hh* *hf* *he* *hd* *hc* *hb* *gv* *gz* *ha* *gx* *gv* *gy*	5473 5473 5473 5473 5473 5477 5473 5473*a*	275.1 250.6 277.7 278.8 272.0 302.9 279.0 272.6 267.3 266.4 265.6 268.1 264.2 263.4	7.7 8.8 13.4 13.1 9.8 17.4 9.5 7.4 10.8 10.9 10.9 12.5 13.9 12.3	278.8 269.2	10.0 10.1
1561 Mar. 30, '05 9^{h}43^{m}	*ci* *cj* *ck*	5489 5491	325.3 326.7 301.2	−14.5 −16.5 16.9	325.2 300.9	−15.4 17.0
1565 Mar. 31, '05 9^{h}43^{m}	*ci* *cj* *ck*	5489 5491	324.7 325.8 300.4	−14.5 16.8 17.2	325.0 301.7	−15.0 17.0
1572 Apr. 1, '05 11^{h}23^{m}	*ci* *cj*	5489	324.5 326.0	−14.9 −17.0	324.7	−15.4

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
1588	*ho*	5510	112°1	18°2	111°7	18 5
Apr. 17, '05	*hn*	5509	68.1	−14.0	67.9	−13.6
9h58m	*hm*	5505*a*	87 9	−13.7	87.9	−13.2
	hl	5502*a*	107.8	−21.5	108.0	−20.9
	hk		110.9	−22.0		
	hj	5501*a*	117.8	−20.9	117.7	−20.5
1590	*hn*		69.1	−13.8		
Apr. 18, '05	*hm*	5505*a*	87.6	−13.8	87.7	−13.4
9h31m	*hj*	5501*a*	117 1	−21.1	117.2	−20.8
1601	*hv*		359.8	−21 5		
Apr. 28, '05	*hp*	5512	350.3	12 4	348.2	12.7
9h37m	*hq*	5512	349 2	13 2		
	hr	5512	347.8	13 2		
	hu	5512	347.0	13 3		
	hs	5512	345.7	12 2		
	ht	5512	343.1	14 8	342.8	14.3
1604	*hp*	5512	351.3	12 7	350.1	12.6
Apr. 29, '05	*hu′*	5512	348.3	12 7	347.5	13.1
10h35m	*ht*	5512	343.0	14 1	342.4	14.4
	hx	5516	249.7	−17 7	249.1	−16.5
1625	*ia*	5539	347.0	13.7	346.6	12.7
May 26, '05	*hz*	5539	342.7	15.5	343.9	14.4
10h10m	*hq*	5540	293.4	4.2	292.2	4.6
1626	*hz*	5539	342.6	15.8	342.3	15.9
May 27, '05	*hy*	5540	294.8	4.8	294.1	5.1
10h03m	*ib*	5540	290.1	3.0	291 3	3 4
1630	*ic*	5540	296.3	6.6	296.1	5.6
May 31, '05	*id*		173.9	10.1		
10h36m	*ie*	5542*a*	172.8	10.0	172.0	10.3
1634	*id*	5542*a*	174.1	10.0	173.3	10.0
June 1, '05	*if*	5542*b*	168.2	9.5	168.8	10.2
10h03m	*ih*		168.3	11.5		
	ig	5543	161.9	13.1	161.4	13.1
1640			174.6	10.5		
June 2, '05	*id*	5542*a*	173.8	10.6	173.5	10.3
11h30m			173.3	10.7		
	if	5542*b*	167.2	9.9	167.9	10.2
	ig	5543	161.0	13.1	161.3	13.1
1644			174.5	10.4		
June 3, '05	*id*	5542*a*	173.7	10.4	173.5	10.6
10h34m			173.0	10.4		
	ij	5542	170.1	11.1	170 0	11 3
	if	5542*b*	167.8	10.1		
			167.2	10.0	166.8	10.3
	ig	5543	166.5	9.9		
			160.8	13.2	161.3	13.8
1648	*id*					
June 5, '05	*id′*	5542*a*	173.9	10.4	173.1	10.6
11h16m			171.6	10.9		
	if	5542*b*	167.4	10.3	167.7	10.7
			167.2	10.3		
	ii		162.5	13.6		
	ik	5542	162.0	11.2	162.1	11.9
	ig		160.7	12.8		
	il	5546*a*	106.8	− 8.7	105.1	− 5.9
1656	*ip*		198.4	24.7		
June 6, '05	*id*	5542*a*	174.0	10.2	172.2	10.5
10h08m	*if*	5542*b*	167.1	10.4	165.3	10.7
	im	5546*a*	109.6	− 8.5	103.2	− 7.4
	in		105.7	− 9.8		
	io	5546	101.5	− 6.9	98.4	− 6.6

TABLE XVIII—*Continued*

Plate Number and Date	Letters	Comparison Star No.	Star's Place		Greenwich	
			Longitude	Latitude	Longitude	Latitude
1662	*ir*	5548	183°3	−18°4	182°5	−17°5
June 8, '05	*s*	5542*b*	167.5	11.0	166.9	11 4
	t	5542	162 4	11 5	162 4	12 0
	u	5546*a*	107 0	− 8.8	106.5	− 8.6
	is	5550*a*	70 0	−16.2	69.8	−15 9
1666	*it*	5550*a*	71 0	−16.2	70.6	−15.9
June 13, '05	*iu*	5552*a*	55 4	19.2	56.1	19 5
	it	5553*a*	53 3	−15.0	52.4	−15.1
1668	*it*	5550*a*	70.7	−16.8	70.5	−15.9
June 14, '05	*iu*	5552*a*	55.7	19.0	55.7	19.4
	it	5553*a*	53.1	−16 0	53.3	−15.1
1677	*ir*	5559*a*	332.7	−23.7	332.1	−22.2
June 15, '05	*is*	5550*a*	71.2	−16.7	70.3	−16.6
	iu	5552*a*	55.5	18.9	56.0	18.9
	it	5553*a*	54.8	−16.2	53.1	−15.7
1682	*ir*	5559*a*	332 0	−23.5	331.9	−23.2
June 16, '05	*is*	5550*a*	71.1	−16.4	70.5	−15.9
	iu	5552*a*	55.4	18.8	55.1	19.1
	it	5553*a*	53.7	−16.0	53.4	−15.3
1686		5559*a*	331.5	−23 3	329.4	−23.1
June 21, '05						
1689	*ix*	5564	258 8	6.5	258.3	6.2
June 22, '05						
1692	*iy*	5564*a*	264.6	5.0	263.6	5.6
June 24, '05	*iz*	5564*b*	255.7	5.5	255.8	5.8
2208	*jd*	6172*a*	78.7	6.1	78.1	6.7
Apr. 27, '07	*je*	6175	54 5	− 8 4	54.0	− 6.9
	jf		53.0	− 7.0		
	jh	6175	57.9	− 6.4	57.3	− 6.1
	jn	6179	55.9	− 3.0	55.3	− 2.5
2220	*jf*	6180	6 3	−22 5	5.0	−22.5
May 2, '07						
2224	*jf*	6181	326 2	− 9.2	325 1	− 8.5
May 4, '07	*jf*	6181	319.8	− 9.1	320 8	− 8.7
2226	*jg*	6181	328 5	− 9.0	327.0	− 8.5
May 6, '07	*jg*		324.5	− 9.7		
	jf	6181	320.1	− 8.4	321.1	− 9.1
	jj	6184	250.3	−10.0	249.4	− 9.7
	jl	6184	246.1	−12.8	245 0	−13.0
2238	*jf*	6181	329 8	− 7.7	329.1	− 7.7
May 7, '07	*jf*	6181	319.7	− 7.9	319.3	− 8.0
	jk	6182	305 5	16.0	305.5	16.0
	jm	6183	247 0	−16 8	247.5	−15.4
	jn	6184*a*	246 1	−13.8	245.6	−13.1
	jo	6185	244 2	4 2	244 0	5 2
2242	*jf*	6181	321 0	− 7.7	319 4	− 7.8
May 8, '07	*jk*	6182	305.1	16 0	305 0	16.3
	jm	6183	248 8	−16 6	247 6	−14 8
	jn	6184*a*	246 0	−13.8	245 6	−12 9
	jp		244 1	−14.4		
	jq	6185	245 3	4 0	244.7	4.9
	jo	6185*b*	241 1	3.5	241 6	3.9

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
2250 May 9, '07 9^h10^m	*jk*	6182	304.5	16?2	304?5	16?8
	jn	6184	247.0	−16.0	247.1	−15.5
	jt		246.5	−13.2		
	jp	6184*a*	245.2	−15.1	246.1	−12.9
			244.2	−14.1		
	jl	6185*a*	247.4	3.9	246.8	4.4
	jo	6185*b*	241.5	3.0	241.1	3.5
			240.6	4.0		
		6185	240.3	4.7	240.3	5.4
2258 May 11, '07 11^h40^m	*jl*	6185*a*	249.0	4.6	248.6	4.8
	jt	6184*a*	246.5	−13.3	245.8	−12.7
	jo	6185*b*	241.6	3.3	241.4	3.7
			240.7	3.9		
	jq	6187	176.8	−11.3	176.0	−11.3
2260 May 13, '07 10^h26^m	*jl*	6185*a*	251.4	4.8	251.2	5.4
	jl′		249.0	5.3		
	jl″	6185	247.6	4.5	247.5	5.2
	jt	6184*a*	247.0	−12.9	246.3	−11.9
	jo	6185*b*	241.0	3.3	241.4	4.6
	jo′		241.4	4.8		
	jr	6187	176.5	−14.3	175.6	−13.7
2265 May 17, '07 10^h56^m	*js*	6187	175.7	−11.6	175.2	−11.0
	jt	6189*a*	82.6	7.4	81.8	8.2
2270 May 18, '07 9^h43^m	*js*	6187	176.4	−11.7	175.7	−11.1
	jt	6189*a*	82.6	7.1	81.7	8.4
2275 May 20, '07 9^h57^m	*jt*	6189*a*	82.3	7.1	82.2	7.9
	ju	6191	56.6	3.2	53.3	4.9
	jv	6190	46.8	− 6.1	45.9	− 5.5
2278 May 21, '07 9^h43^m	*jt*	6189*a*	82.3	7.2	82.4	7.7
	ju	6191	57.2	3.1	56.7	3.6
	jv	6190	47.5	− 5.9	47.1	− 5.5
2292 June 5, '07 10^h14^m	*jw*	6197*a*	271.3	−16.3	270.7	−15.9
2298 June 6, '07 $10^h23^m.5$	*jw*	6197*a*	271.4	−16.8	270.8	−15.9
2301 June 8, '07 9^h52^m	*jw*	6197*a*	271.5	−16.0	272.6	−15.8
2309 June 13, '07 $10^h37^m.5$	*kc*	6202	109.8	11.0	109.8	11.6
	kb	6202	115.6	9.8	116.0	10.7
	ka	6203	131.5	6.3	131.0	6.6
	jz	6202	117.4	10.2	116.0	10.7
	jy	6204	117.0	−21.9	117.5	−21.2
	jx	6201*a*	127.3	−20.3	126.9	−19.6
2314 June 14, '07 9^h45^m	*kd*	6205*a*	69.5	−17.0	69.3	−16.8
	kc	6202	109.9	11.3	109.8	11.4
			109.7	12.1		
	jz	6202	117.7	10.8	116.9	11.0
	jy	6204	117.2	−21.1	117.0	−20.9
	jx	6201*a*	127.4	−20.0	127.1	−19.7

TABLE XXIII—Continued

Plate Number and Date	Station	Star Number	Comparison Star		Greenwich	
			Longitude	Latitude	Longitude	Latitude
2338	*ka*	6205	68.7	−12.0	61.2	−11.8
June 15, '07	*kd*	6205*a*	68.9	−17.2	69.0	−16.8
9h42m	*a*	6202	109.8	11.4	109.1	11.7
	b	6202	118.2	11.3	117.6	11.3
	c	6201	117.1	−21.0	116.7	−20.8
	f	6201	127.4	−20.0	127.0	−19.6
2324	*ka*	6205	67.5	−15.2		
June 17, '07	*kg*	6205	65.9	−12.2	66.1	−14.3
9h14m			63.2	−14.8		
	kd	6205	68.6	−17.1	68.7	−17.0
	kf	6205	69.9	−19.5		
			68.7	−19.0		
	kc	6205*c*	60.5	−11.6	60.7	−11.7
	b	6204	116.5	−21.7	116.7	−21.4
	f	6201*a*	127.6	−19.3	127.1	−19.6
2329	*a*	6202	109.9	11.4	109.4	11.6
June 18, '07	*kg*	6205	64.6	−15.6	63.1	−13.2
10h02m	*kd*	6205	67.2	−15.8	65.1	−16.7
	kf		70.8	−19.5		
	kc	6205*c*	60.2	−11.8	60.5	−10.8
		6205	68.9	−17.1	67.8	−15.3
	c	6202	119.1	11.9	118.9	12.1
	f	6201	116.5	−22.1	115.8	−21.5
2361	*ka*	6205	71.1	−15.9		
June 19, '07	*kg*	6205	65.0	−13.2	66.2	−13.8
11h52m			66.1	−13.0		
			67.3	−15.2		
	kf	6205	71.9	−19.6	71.1	−18.5
	kc	6205	60.5	−11.3	60.3	−10.9
	kd	6205	68.8	−17.0	68.6	−16.5
	a	6202	119.9	12.0	119.4	12.3
	b	6202	117.3	11.5	116.8	11.7
2335	*ka*	6205	71.9	−15.4	71.5	−13.2
June 20, '07	*kg*	6205	61.7	−12.5	61.1	−12.1
9h24m		6205	67.0	−14.8	66.0	−13.7
	kf	6205	71.7	−19.4	71.8	−18.1
	kc	6205	59.8	−11.2	59.6	−10.4
	kd	6205	68.8	−16.8	68.6	−16.6
2339			58.8	−10.6		
June 22, '07			60.8	−11.3		
9h18m			61.9	−11.5	61.1	−11.3
	kc	6205*c*	59.6	−12.0		
			60.8	−12.8		
			62.8	−12.4		
	ka	6205	66.8	−15.7	66.2	−13.7
	kg	6205	68.7	−17.1	68.0	−16.6
2352	*kc*	6205	271.5	3.4	270.9	3.8
June 26, '07						
11h30m						
2353	*kc*	6205	271.4	3.7	270.7	3.8
June 27, '07						
9h30m						
	kc	6205	272.6	4.0	271.9	
June 28, '07						3.2
9h20m	*kc*	6205	273.7	4.8	272.9	
June 29, '07						4.0
9h39m						

TABLE XVIII —*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Ca	
			Longitude	Latitude	Longitude	Latitude
2369	*kk*	6211	190 9	+ 3 0	189 2	2 9
July 2, '07	*kj*	6210*a*	288 3	11 9	287 6	12 1
9^h17^m						
2375	*km*	6212	182 2	− 7 9	180 7	− 6 8
July 3, '07		6211	187 5	3 5	187 7	4 4
2^h56^m	*ll*	6211	188 9	3 4		
			187 0	5 8	188 0	6 0
	kk	6211	189 3	4 5		
			193 0	3 0	191 0	4 2
2401	*kp*	6223	248 2	7 0	246 5	7 9
July 26, '07	*ko*	6223	253 7	7 2	251 9	6 7
11^h28^m	*kn*	6220*c*	303 9	7 9	301 9	− 7 8
2403	*kp*	6223	248 7	7 3	248 8	7 5
July 27, '07	*ko*	6223	254 1	7 1		
9^h15^m			254 9	6 8	253 3	6 7
	kn	6220*c*	304 6	− 8 1	303 5	− 7 5
2406	*kt*	6226*a*	194 9	− 7 5	194 4	7 9
July 29, '07	*ks*	6225*a*	201 9	9 6	201 2	9 5
9^h45^m	*kr*	6223	257 7	−13 2	256 1	13 1
	kr′		256 5	−13 9		
	kq	6223	258 7	−13 2	258 1	13 3
	ko	6223	255 5	6 1	254 8	6 6
	kn	6220*c*	305 0	− 8 2	304 1	− 7 5
2411	*kn*	6227*a*	185 4	9 2	185 0	9 2
July 30, '07	*kt*	6226*a*	196 4	− 8 4	196 1	8 5
9^h06^m	*ks*	6225*a*	202 2	9 7	201 7	9 6
	kq	6223	259 8	−13 7	259 2	13 1
	ko	6223	256 9	5 9	256 7	7 0
	kn	6220*c*	305 9	− 8 1	304 7	− 7 8
2417	*kn*	6227*a*	185 0	− 9 9	184 6	9 3
July 31, '07	*kt*	6226*a*	197 3	− 9 0	196 6	8 5
11^h46^m	*ks*	6225*a*	202 0	9 4	201 3	9 8
	ko	6223	258 1	6 7	257 4	7 3
2420	*kr*	6226	193 8	− 8 2	193 4	− 7 9
Aug. 1, '07	*kn*	6227*a*	184 5	− 9 9	184 3	− 9 6
11^h42^m	*kt*	6226*a*	198 5	− 8 7	197 4	− 8 5
	ks	6225*a*	201 7	9 4	201 1	9 6
	ko	6223	259 0	6 4	257 8	7 5
2423	*kn*	6227*a*	184 3	9 8	183 8	9 7
Aug. 2, '07	*kt*	6226*a*	199 5	8 5	198 9	8 3
10^h04^m	*ks*	6225*a*	201 5	8 1	201 2	9 7
	ko	6223	260 6	6 4	258 7	7 1
2427	*kx*	6229*a*	166 9	− 9 9	166 5	− 9 6
Aug. 3, '07	*kw*	6223	252 3	8 5	250 7	8 8
9^h40^m	*kn*	6227*a*	183 7	−10 1	183 9	− 9 7
	kt	6226*a*	200 7	− 9 0	200 0	− 8 6
	ks	6225*a*	201 3	9 1	201 1	9 7
2434	*lb*	6233*a*	58 1	−19 4	57 8	−19 8
Aug. 9, '07	*la*	6232*a*	89 9	−14 4	89 3	−14 1
9^h08^m			142 2	6 1		
	kz	6231	142 7	6 8		
			142 7	8 7	143 3	7 5
	ky	6231*a*	140 9	7 0		
			147 2	8 3	146 4	8 6
2451	*lb*	6233*a*	58 2	−19 3	57 9	−19 2
Aug. 10, '07	*la*	6232*a*	90 2	−14 3	89 5	−13 8
11^h54^m			142 9	6 6		
	kz	6231*b*	141 8	8 1		
			141 7	8 1	141 6	7 4
			142 2	5 5		

TABLE XVIII (Continued)

Plate Number and Date	Letter	Comparison Star Number	Spectrograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
2452	*k*	6234*c*	27.5	15.1	26.5	14.9
Aug. 12, '07	*lh*	6233*a*	57.3	−19.7	57.0	−19.3
10h00m						
2460	*lf*	6235*a*	94.6	17.8	94.0	19.0
Aug. 14, '07	*k*	6234*a*	27.5	15.0	26.8	15.3
9h50m	*lh*	6233*a*	57.3	−19.7	57.4	−19.1
2465	*k*	6236*a*	326.1	−27.2	325.5	−27.0
Aug. 16, '07	*le*	6236	333.2	−21.8	333.0	−21.1
10h53m	*lf*	6236*a*	339.0	−23.5	338.5	−23.0
	lc	6234	27.7	14.9	27.2	15.8
	lh	6233*a*	56.5	−20.0	55.9	−19.2
2468	*li*	6238*a*	309.8	− 8.2	309.9	− 8.0
Aug. 17, '07	*le*	6236*b*	325.2	−26.9	325.5	−26.2
11h30m		6236	327.6	−25.7	328.3	−24.5
		6236	333.1	−21.5	333.5	−20.6
	lf	6236	336.3	−21.4	335.2	−21.9
	lf	6236*a*	338.6	−23.5	338.7	−22.7
	lc	6234	27.7	15.0	26.9	15.4
	lb	6233*a*	56.2	−20.0	54.7	−19.0
2470	*lj*	6239*a*	264.8	−13.7	264.7	−13.4
Aug. 22, '07	*li*	6238*a*	311.0	− 8.1	310.6	− 7.5
10h11m	*le*	6236	325.1	−25.8	324.8	−24.7
	lg	6236	330.7	−24.0	330.6	−23.2
	lf	6236*a*	335.2 336.6 338.0 339.7	−24.8 −24.0 −21.0 −21.5	330.1	−23.4
2477	*lk*	6240	263.4	− 9.2	265.8	− 8.1
Aug. 23, '07	*lj*	6239*a*	265.1	−13.7	264.5	−13.7
9h31m	*li*	6238*a*	311.3	− 8.5	311.1	− 7.7
	lk	6236	326.0	−26.0	324.1	−24.7
	lg	6236	330.7	−24.4	332.0	−22.8
	lf	6236*a*	337.6 336.0 333.7	−24.4 −22.2 −22.8	336.3	−23.7
2480	*lm*	6239	231.7	−13.2	231.5	−13.0
Aug. 24, '07	*lk*		241.6	−12.7		
9h07m	*lj*	6239*a*	264.8	−13.8	264.5	−13.1
	li	6238*a*	311.9	− 8.6	310.9	− 7.9
	lg	6236	330.7	−24.2	329.2	−23.4
2501	*lc*	6254	5.3	9.0	4.9	9.1
Sept. 12, '07	*lm*	6252*b*	24.3	4.2	24.1	− 6.6
10h48m	*ln*	6252*c*	25.4	− 4.0	24.9	− 4.2
		6252	26.4	− 4.0	26.5	− 5.7
	lk	6252*b*	29.8	− 6.0	28.8	− 6.0
	lq	6247*a*	38.2	− 7.9	37.3	− 7.4
	lp	6251*b*	84.8	25.8	84.0	26.2
2505	*ln*	6256*a*	308.6	7.0	308.4	6.9
Sept. 13, '07	*lg*	6253*c*	326.8	−23.8	327.1	−23.5
10h	*lk*	6253*a*	5.3	9.0	5.2	9.0
		6252*c*	24.5	− 3.9	23.9	− 3.7
	lf	6252*a*	22.7	− 6.0	23.4	− 6.5
			24.3	− 7.9		
	lr	6247*a*	30.4	− 5.9	29.8	− 5.5
	lq	6247*a*	38.0	− 8.0	37.4	− 7.4
2510	*ln*	6256*a*	309.0	6.5	308.1	6.6
Sept. 14, '07	*lg*	6253*c*	326.6	−23.8	326.2	−23.7
9h	*lk*	6253*a*	6.3	9.2	5.7	9.3
		6252*c*	25.3	− 4.2	26.2	− 4.3
	lf	6252*a*	23.3	− 5.2	24.2	− 3.5
		6252	23.3	− 6.9	22.6	− 6.0
	lr	6247*a*	31.3	− 6.3	30.0	− 5.6
	lq	6247*a*	38.3	− 8.2	37.1	− 7.5

TABLE XVIII —*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectrohelliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
2538*a*	*lw*		46°8	−10°0		
Oct. 8, '07	*lx*	6273*a*	36.9	− 6.0	36°7	− 6°2
9^h32^m	*lz*	6276	356.5	−23.8	353.1	−23.7
2542	*lw*	6275*a*	48.4	− 9.3	47.6	− 9.5
Oct. 9, '07	*lx*	6273*a*	37.2	− 6.0	37.3	− 5.9
10^h23^m	*lq*	6275*b*	42.3	− 9.2	42.9	− 9.1
	lz	6276	358.6	−24.0	357.5	−23.2
	ma	6276	356.2	−24.0	355.6	−23.5
	mb	6276	352.5	−22.7	352.6	−22.4
2551	*mc*	6279*a*	315.1	− 6.5	315.2	− 6.0
Oct. 17, '07	*md*	6280*a*	311.3	7.2	310.6	7.7
11^h05^m	*mf*	6282*b*	254.3	5.9	254.1	6.1
	mg	6282*c*	252.4	5.7	252.0	5.4
	mh	6283*a*	{238.6	8.4}	237.9	8.2
	mi		{237.3	7.9}		
	mj	6283	237.6	10.6	236.9	10.4
	mk	6283*b*	232.2	8.2	232.4	8.1
	ml	6284*a*	228.8	8.3	228.1	8.0
	mm	6285*a*	220.8	10.8	220.8	10.7
2554	*mc*	6279*a*	317.1	− 6.6	315.9	− 6.2
Oct. 18, '07	*md*	6280*a*	311.8	7.6	311.4	7.9
10^h08^m	*mf*	6282*b*	254.9	6.1	254.1	6.2
	mg	6282*d*	252.6	5.4	252.1	5.0
	mh	6283*a*	238.3	8.2	237.8	8.8
	mi					
	mj	6283	237.6	10.4	235.0	9.1
	mk	6283*b*	232.5	8.3	232.0	8.4
	ml	6284*a*	228.8	8.2	228.3	8.1
	mm	6285*a*	220.9	10.6	220.9	10.6
2557	*mg*	6282*d*	254.4	4.1	253.0	4.2
Oct. 21, '07	*mf*	6282*b*	255.9	5.1	254.5	5.7
10^h33^m2	*mo*	6283	241.9	9.1	240.2	10.2
	mh	6283*a*	239.0	8.1	237.7	8.4
	mk	6284*a*	{229.8	7.3}	227.7	7.8
	ml		{228.3	7.5}		
	mn	6285*b*	222.5	9.1	221.5	9.0
	mm	6285*a*	221.8	10.7	220.8	10.7
	mp	6285*c*	219.7	10.1	218.2	10.3
2560	*mf*	6282*b*	255.8	6.0	254.4	5.6
Oct. 22, '07	*mg*	6282*d*	{254.4	5.2}	253.0	4.0
10^h32^m			254.5	4.0}		
	mh	6283*a*	238.9	8.7	237.6	8.6
	mk	6284*b*	230.1	7.7	228.7	7.5
	ml	6284*c*	228.3	8.0	227.3	8.1
	mm	6285*a*	221.9	11.2	220.9	10.9
	mo	6283	243.6	9.0	242.3	8.9
	ms		236.5	10.1		
2564	*mf*	6282*b*	256.4	4.7	255.4	6.2
Oct. 23, '07	*mg*	6282*d*	254.8	4.8	254.5	3.9
11^h00^m	*mh*	6283*a*	239.2	8.1	238.7	9.2
	ms	6283	237.0	9.8	236.6	10.1
	mk	6284*b*	230.5	7.3	229.9	7.8
	ml	6284*c*	228.5	7.7	228.4	8.3
	mm	6285*a*	220.8	11.0	221.8	11.3
	mr	6289*a*	143.1	−15.9	142.3	−16.3
2568	*mr*	6289*a*	143.6	−16.1	143.1	−17.0
Oct. 25, '07						
9^h51^m						
2615	*mu*	6323*a*	223.1	−16.0	220.8	−15.6
Dec. 19, '07	*mv*	6323*b*	213.8	−15.3	212.6	−15.6
11^h23^m	*mw*	6325	184.4	−18.8	182.6	−18.0
	mx	6324*a*	143.6	− 5.1	143.5	− 5.0

TABLE XVIII—*Continued*

Plate Number and Date	Comparison	Observation Number	Spectrum-Reduction		Greenwich	
			Longitude	Latitude	Longitude	Latitude
[illegible]	[illegible]	[illegible]	214°6	−15°8	215°3	−15°4
[illegible]	[illegible]	6325	186 2	−18 8	184.9	−18.7
[illegible]	[illegible]	[illegible]	143.7	− 5.4	143.6	− 5.0
[illegible]	[illegible]	[illegible]	307.4	− 4.0	306 6	− 3.0
[illegible]	[illegible]	[illegible]	294.6	− 8.7	293.8	− 8.1
[illegible]	[illegible]	6406*a*	307.6	− 3.3	306.9	− 2.8
Apr. 21, '08	[illegible]	6407*a*	294 9	− 8.0	294.3	− 7.5
[illegible]	[illegible]	6406*a*	308.2	− 2 2	306.9	− 2.7
[illegible]	[illegible]	6407*a*	295 1	− 7 3	294.5	− 7.8
2702	[illegible]	6436*a*	332 4	11.3	332.0	11.2
May 20, '08						
2705	[illegible]	6436*a*	332.1	11.4	331.9	11.5
May 21, '08						
[illegible]	[illegible]	6436*a*	332 4	12.0	331.9	11.5
May 22, '08	[illegible]	6438	322.1	−21.5	321.0	21.7
2714	*nd*	6440*a*	159.1	−15.0	158.6	−14.7
June 1, '08	[illegible]	6441*a*	144.7	− 3 2	144.0	− 2.8
[illegible]	*nf*	6446*a*	104.4	−11.8	103.9	−11.2
	[illegible]	6445*a*	106.6 105 5	11.5 11.0	105.4	11.5
	[illegible]	6447	100.5	11.4	100.6	11.0
	[illegible]	6449*a*	186.7	− 9.1	186.2	− 9.1
	[illegible]	6449*b*	183.8	− 9.6	183.6	− 9.3
	[illegible]	6450	144.9	10 1	144.5	10.4
2719	[illegible]	6440*a*	158.8	−14.9	158.4	−14.6
June 2, '08	[illegible]	6441*a*	144.9	− 3.0	144.1	− 3.2
[illegible]	[illegible]	6446*a*	105.4	−11.2	105.1	−11.1
	[illegible]	6448*a* 6448*b*	94.4	−11.3	96.9 93.8	−11.8 −10.6
	[illegible]	6445*a*	107.4 106.3 104 7	11.0 11.1 10.9	105.9	11.1
	ni	6447	100.6	12 0	100.5	10.8
	[illegible]	6450	146.1	10 0	145.7	9.8
2725	*ne*	6441*a*	146.0	− 2.9	145.1	− 2.9
June 4, '08	*nd*	6440*a*	158 8	−14.6	158.0	−14.2
[illegible]	[illegible]	6448*a*	93 8 93.2 94.1	−10.7 −11.5 −12.9	94.1	−11.6
	[illegible]	6445*a*	108.5 106.7	10.3 10.2	107.4	10.7
	[illegible]	6445	105 9 105 0	10 0 10 3	104.8	10.7
	[illegible]	6447	100 8	12.2	100.7	12.0
	[illegible]	6448*a*	100.0	−11.2	99.1	−11.6
[illegible]	[illegible]	6441*a*	147 0	− 3 0	145 4	− 2.8
[illegible]	[illegible]	6446*a*	107 2	−10 9	107 0	−10.6
	[illegible]	6448*a*	95 5 94 0	−11 1 −12 2	94 0	−11 5
	[illegible]	6445	109 6	10 1	108 8	10 2
	[illegible]	6445	107 4	10 1	106 3	10 2
	[illegible]	6447	100 2	12.1	100 6	12 3
	[illegible]	6448	102 0	−10 9	101.2	−10 6
	[illegible]	6448*a*	99 7	−11 5	99 2	−11 6
	nm	6441	103 8	−17 0	101 8	−16 9

TABLE XVIII -*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
2733 June 6, '08 10^h10^m	*nf*	6446*a*	{108°8 107.0	−10°4 −10.9	107°2	−10°6
	ng	{6448*c* 6448*d*	93.8 93.2	−12.2 −11.3	94.5 93.7	−12.3 −10.7
	nh	6445*a*	110.4	10 2	109 5	10.5
	nj	6447	101.2	12.4	100.7	12.7
	nl	6448	102 8	−10 7	101.7	−10.7
	nm	6451	104.2	−17 0	102.9	−16.9
	nn	6451	101.7	−17 1	99.1	−17.7
2748 June 15, '08 11^h44^m1	*no*	6453*a*	333.7	10.0	333 3	10.2
2753 June 16, '08 10^h12^m2	*no*	6453*a*	333.7	10 2	333.2	10.5
2768 June 24, '08 9^h55^m3	*np*	6464*a*	154.1	− 2.5	153 8	− 2.7
	nr		226 8	−19.3		
2774 June 25, '08 9^h56^m9	*np*	6464*a*	154.3	− 2.9	153.6	− 2.4
	nr	6463	227.6	−18.8	225.9	−18 8
2781 June 26, '08 9^h26^m0	*np*	6464*a*	153.7	− 2.6	153 9	− 2.9
	nq	6465*a*	131.4	−14 8	131.4	−15.4
2789 June 27, '08 8^h57^m7	*np*	6464*a*	154.4	− 3.0	153 7	− 2.9
	nq	6465*a*	131.3	−15.2	131.1	−15.0
2805 July 8, '08 9^h21^m	*ns*	6472*a*	354.4	10.1	353.6	9.7
2809 July 9, '08 9^h23^m8	*ns*	6472*a*	353.4	10.2	354.8	10.3
2813 July 10, '08 2^h18^m0	*ns*	6472*a*	354.7	10.0	355.0	10.6
2820 July 11, '08 10^h45^m6	*ns*	6472*a*	355.3	11.2	254.5	10.6
2837 July 15, '08 10^h33^m6	*nt*	6480*a*	320.0	−15.1	318.6	−14.7
	nu	6478	234.5	−20.2	233.4	−20.6
2840 July 21, '08 10^h16^m2	*nu*	6478*a*	237.1	−20.7	236.4	−20.6
	nu'	6478	234.6	−18 2	234.8	−18.3
	nv'	6481	226.1	−20 0	226.0	−19.2
	nw	6482	251.9	− 1 9	253.0	− 2.3
	nx	6482	250.6	− 3 1	250.5	− 2.7
	ny	6482	247.9	− 3 1	248.6	− 2.3
	nz	6482	248.8	− 0 9	248.8	− 0.9
	oa		249.5	13 0		
	ob		249.0	14.7		
	oc		243.3	13.2		
	od	6486	243.3	14.9	243.5	15.4
	oa'		247.4	13.1		

TABLE XVIII—*Continued*

Planet Number and Date	Comparison	Comparison Number	Correction to Ephemeris		Observed	
			Longitude	Latitude	Longitude	Latitude
2845	*ak*	6478*a*	236°.5	−20°.5	237°.0	−20°.0
July 22, '08	*al*	6481	225.9	−20.0	226.4	−19.7
9h27m4	*am*	6482	252.7	− 2.0	250.1	− 4.0
	an		250.4	− 3.0		
	ao		247.4	− 2.9		
	ap	6482	248.5	− 0.8	249.5	1.1
	aq	6486	249.5	13.1	248.2	14.3
	ar	6486	242.8	15.0	243.6	15.9
	as		248.8	− 4.8		
	at	6487*a*	159.7	10.7	158.7	10.3
	ag	6488	154.6	12.5	154.5	12.0
2862	*ah*	6489*a*	127.1	−17.3	127.5	−17.7
July 27, '08						
9h44m2						
2876	*ai*	6489*a*	127.4	−17.4	127.2	−17.3
July 28, '08						
9h31m5						
2884	*aj*	6489*a*	127.2	−17.0	127.0	−17.1
July 29, '08						
11h58m8						
2889	*ah*	6489*a*	127.4	−17.2	126.2	−16.4
July 31, '08	*ai*	6490*a*	29.6	−13.2	28.9	−13.4
10h57m1	*aj*		28.7	−14.1		
2894	*ah*	6489*a*	127.8	−16.9	126.1	−16.6
Aug. 1, '08	*ai*	6490*a*	29.8	−12.8	29.0	−13.0
9h20m7	*aj*		28.9	−13.8		
	ak	6491*a*	2.3	11.3	0.5	11.6
	am	6490	27.6	−15.0	26.7	−15.1
	an		27.2	−16.0		
2903	*ai*	6490*a*	29.7	−12.7	29.3	−12.8
Aug. 3, '08	*aj*		28.8	−13.5		
10h01m0	*ak*	6491*a*	0.9	11.1	0.5	11.4
	am	6490*b*	28.2	−16.0	27.2	−15.4
	an	6490*c*	22.6	−16.0	23.1	−16.1
	ao	6490*d*	19.6	−19.0	20.3	−19.6
	ap		21.3	−20.0		
	aq	6492*a*	26.4	7.5	25.2	8.0
	ar		25.4	8.0		
	as	6492*b*	22.2	8.8	22.0	8.6
	at		22.3	7.8		
2912	*ai*	6490*a*	29.9	−13.0	28.9	−12.8
Aug. 4, '08	*aj*		2.9	11.8		
9h57m8			1.7	11.9		
	ak	6491*a*	359.7	13.2	0.5	12.2
			0.6	12.2		
			1.0	10.9		
			0.7	12.0		
	am	6490	28.2	−15.0	26.6	−15.3
	an	6490	27.9	−17.0		
	ao	6490	21.9	−16.0	21.7	−15.7
	ap	6492	19.7	−19.5	20.1	−18.7
	aq		20.7	−20.1		
	ar	6492*a*	27.6	7.7	26.1	8.2
	as	6492	22.3	9.0	22.4	9.3
	at	6492	22.1	7.7	22.0	7.8
	au	6494	347.8	− 7.7	345.7	−7.2
	av	6494	345.7	− 7.9	342.8	−7.4

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
2915 Aug. 5, '08 8^h55^m8	*oi'*	6493	37.6	−10°0	36°1	−10°0
	oi	6490*a*	30.1	−13.0	28.8	−13.1
	ol		29.8	−13.8		
	om		27 8	−15.0		
	on	6490*bc*	28.5	−17.0	24.0	−16.1
	oo		21.6	−16.3		
	op	6490*d*	19 2	−19.7	20.2	−19.1
	or	6492*a*	28.1	8.1	26.9	7.3
	os	6492*b*	22.6	8.8	22.4	9.0
	ot	6492*c*	21.8	7.2	21.5	7 3
	ou	6494	348.8	− 8.0	347.6	− 7.0
	ov	6494	341.9	− 8.0	342.0	− 7.3
			2.6	11.0		
			1.5	11.8		
	ok	6491*a*	359.8	12.9	0.3	11.8
			0.3	12.1		
			0.7	10.7		
			0.5	11.6		
2946 Aug. 13, '08 9^h32^m8	*ow*	6498	318.9	−10.9	317.7	−10.9
	ox	6499	272.6	− 5.1	270.6	− 5.2
	oy	6499	268 5	− 4.1	267 8	− 4.7
	oz	6499	266 6	− 5 0	266.1	− 4.7
2955 Aug. 14, '08 11^h48^m2			271 9	− 5 0		
	ox	6499*a*	273.9	− 5 2	273.1	5 1
			272.7	− 6 1		
	oy	6499	268.1	− 4.5	268.0	4 3
	oz	6499*b*	266.8	− 5.5	266.9	− 5.6
	pa	6500	208.1	−16.2	207.2	−15.0
	pb	6500	205.2	−14.1	204.8	−14.1
2968 Aug. 21, '08 10^h39^m5	*pa*	6500*a*	209.4	−15.1	208.7	−14.6
	pb'	6503	190.6	−12.6	189.3	−12.6
	pd		189.3	−12.8		
	pe	6503	187.7	−14.5	186.7	−14.6
	pf	6503	183.4	−17.7	183.3	−16.7
			182.0	−17.2		
			182 2	−15.9		
			183.3	−18.5		
	pg	6505	183.9	19.2	183.2	18.7
2971 Aug. 22, '08 9^h17^m0	*pb'*					
	pd	6503	191.5	−13.0	189.4	−12.4
			189.7	−12.7		
	pe	6503	188.9	−14.2	187.2	−14.0
	pf	6503	183.8	−17.2	182.0	−16.9
	pg	6505	184.1	19.0	183.5	19.2
	pb''	6506	200.4	−22.5	197.8	−22.5
	pe'	6506	194.7	−21.7	193.3	−21.1
2979 Aug. 25, '08 10^h43^m3	*ph*	6507*a*	142.1	−18.8	140.9	−18.4
	pi	6507*b*	141 2	−18.9	135.2	−18.1
			135.6	−18.5		
2986 Aug. 26, '08 3^h14^m5	*ph*	6507*a*	142.6	−18.7	141.7	−18.3
	pi	6507*b*	135.6	−18.0	135.5	−18.0
	pj	6510	39.0	5.8	38.5	5.0
	pk	6510	30.6	8.0	30.0	7.0
	pl	6511*a*	31.4	−12.6	30.0	−14.0
	pm		74.1	−12.4	. . .	. . .
	pn		70.9	−13.0	. . .	. . .

TABLE XVIII—*Continued*

Plate Number and Date	Object	Greenwich Number	Spectrophotographic		Greenwich	
			Longitude	Latitude	Longitude	Latitude
2987	*pc*	6507*b*	137°2	−18°8	134°9	−18°1
Aug. 27, '08	*pj*	6510	39.5	5.3	38.5	5.2
9h25m5	*pk*	6511*a*	31.7	−13.2	30.8	−13.6
	pl	6510	31.1 29.7 31.2	8.1 7.5 6.6	31.3	6.6
	pm	6512	74.5	−13.3	73.7	−12.7
	pn	6512	70.7	−13.6	70.9	−13.3
	po	6513	22.5 20.3	18.8 19.0	20.6	18.6
	pp	6514	22.7	0.9	121.9	1.2
	pq	6515	117.3	− 8.6	115.9	− 8.2
	pr	6515	113.7	− 9.1	113.2	− 8.9
2989	*pj*	6510	40.0	5.0	39.3	4.7
Aug. 28, '08	*pk*	6510	31.3 30.0	6.6 7.4	31.3	6.8
10h10m2	*pl*	6510	28.8	9.0	29.8	9.8
	pl	6511*a*	32.1 30.0	−13.2 −13.5	30.8	−13.6
	pm	6512	70.2	−12.9	70.7	−13.0
	pn	6513*a*	22.5	18.2	21.8	18.3
	po	6513*b*	20.5	18.8	19.8	18.7
	pt	6516	16.0	−15.9	14.9	−16.0
3005	*pj*	6510	39.8	5.0	39.2	4.8
Aug. 29, '08	*pk*	6510	31.2 29.7 30.8 32.3	6.2 7.4 8.1 8.0	30.3	7.4
9h40m0	*pl*	6511*a*	31.7 29.9	−13.4 −13.4	31.2	−13.3
	pn	6513*a*	22.6	18.7	21.8	18.3
	pt	6516	15.2	−15.8	14.7	−15.7
	pu	6517*a*	355.2	− 6.3	354.7	− 6.3
3013	*pj*	6510	39.6	5.5	40.4	4.7
Aug. 31, '08		6510	27.6	9.1	28.2	9.9
9h28m7	*pk*	6510	29.5	7.2	29.6	8.0
		6510	31.4	5.8	31.2	5.4
		6510	31.2	7.9	32.5	8.4
	pl	6511*a*	31.2	−14.1	31.5	−13.7
	pn	6513*a*	22.7	19.0	22.4	19.2
	pt	6516	14.7	−16.1	14.8	−15.9
	pu	6517*a*	354.8	− 7.6	354.7	− 6.5
	pw	6518	2.5	12.8	1.6	12.8
	pv	6510	36.4	8.6	35.7	8.8
	pz	6510	38.4	6.2	37.2	5.8
	pz	6510	35.1	5.8	35.4	6.1
	qa	6518	0.5	13.9	359.8	13.8
	qa	6518	358.7	15.0	358.6	14.6
	qb	6518	356.7 357.7	13.2 13.0	357.1	13.2
	qc	6510	41.7	3.6	43.1	3.3
3025	*pj*	6510	41.5	5.5	40.5	5.2
Sept. 1, '08	*pk*	6510	40.4	5.0	39.2	3.2
9h15m3		6510	27.9	8.8	28.6	9.9
		6510	30.1	7.7	29.7	7.8
		6510	32.0	5.8	31.7	5.9
	pl	6511*a*	31.6	−14.0	31.2	−13.7
	pu	6517*a*	354.8	− 6.1	355.0	6.3
	pw	6518	2.3	13.5	1.7	13.1
	pw	6510	38.8	8.5	37.7	8.7
	pz	6510	36.6	6.2	38.9	7.4
	qb	6518	357.1	14.2	357.6	14.0
	qd	6510	44.1	3.0	42.4	3.3

TABLE XVIII *Continued*

Plate Number and Date	Letter	Greenwich Number	Spectrohelograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
3033						
Sept. 2, '08	*pj*	6510	40 6	5 0	41 7	5 1
10^h02^m8		6510	41 4	6 9	40 3	7 3
	pk	6510	31 3	6 0	31 4	5 1
		6510	30 5	8 1	29 7	8 0
			29 1	10 1	28.7	10 0
	pl	6511*a*	28 3	8 7	. . .	. . . . .
	pu	6517*a*	31 9	−13 5	30 8	-13 6
	pv	6518	355 2	− 6 1	354.9	− 6 2
	pw	6510	1 2	13 0	1 7	13 1
	px	6510	39 4	8 4	38 0	9 0
	qb	6518	38 9	6 0	38 2	5 4
	qd	6510	357 0	14 2	357 5	14 5
	qe	6511*b*	44 2	3 3	43 2	3 5
	qf	6511*b*	28 0	-14 7	27 6	-15 8
			28 3	−17 0	30 3	−16 6
3039						
Sept. 3, '08			41 1	4 5		
9^h32^m2	*pj*		42 1	7 0	. . .	. . . . .
			43 7	4 8	. . .	. . . . .
			43 1	3 1	. . .	. . . . .
		6510	32 4	6 0		. . . . .
	pk	6510	31 0	7 7	31 6	6 3
		6510	29 2	10 3	29 8	8 2
		6510	28 4	8 6	29 7	10 4
	pl	6511*a*	31 7	−14 0	28 1	9 1
	pu	6517*a*	355 5	− 6 2	31 0	13 6
	pv	6518	2 8	13 0	354 9	− 6 5
	pw	.	40 0	8 5	1 7	12 8
	px	.	39 5	5 7	.	. . . . .
	qd	6510	45 0	3 2	43 7	. . . . .
						3 8
3044						
Sept. 4, '08	*pk*	6510	28 8	9 9	28 9	10 8
11^h03^m9			28 5	7 9	28 5	9.0
	pl	6511*a*	31 0	7 0	31 1	8 6
	pl'	6511	31 8	−14 3	30 9	−13 4
	pu	6517*a*	35 0	−16 0	32 8	−15 0
	pv	6518	355 8	− 6 9	355 0	− 6 4
	pw	6510	2 2	12 3	2 0	12 9
	qg	6519*a*	39.7	8 1	38 8	9 2
	qi	6518	289 8	− 5 4	279 8	− 5 9
			259 4	13 7	359 7	13 4
3048						
Sept. 5, '08	*pu*	6517*a*	355.5	− 7 0	355 1	− 6.6
10^h22^m4	*pv*	6518	2 3	13 1		
			1 8	12 7	1 2	12.7
	qg	6519*a*	280 0	− 6 1	279 7	− 5 8
	qh	6520*a*	264 8	14 6	263 8	14 3
3058						
Sept. 8,'08	*qg*	6519*a*	280 4	− 5 9	279 7	− 5.7
10^h48^m2	*qh*	6520*a*	267 8	12 9		
			266 3	9 0	266 5	13.4
	qj	6523*a*	286 4	9 1	285 9	9 5
	qk	6523*b*	281 3	7 5	280 6	7 8
	ql	6522	259 0	14 1	257 9	14 3
	qm	6524*a*	236 2	-14 0	235 7	−13 8
	qn	6524*b*	233 0	−14 2	233 0	−13 0
3062						
Sept. 9, '08	*qg*	6519*a*	280.3	− 5.9	279.7	− 5.6
10^h30^m4	*qh*	6520*a*	269.0	11.9	267.9	11.7
	qk	6523*b*	281.8	7.2	280.9	7.8
			281.2	8.0		
	ql	6522	258.1	14.3	257 4	14.6
		6522	257.4	16.2	257.3	16.5
	qm	6524*a*	236.7	−13.6	236.1	−13.6
	qn	6524*b*	232.1	−13.7	232.2	−13.8

TABLE XVIII—Continued

Plate Number and Date	Letter	Catalogue Number	Solar Equatorial Axis		Greenwich	
			Longitude	Latitude	Longitude	Latitude
3070	*qg*	6519*a*	280.5	− 5.9	279.8	− 5.6
Sept. 10, '08			270.9	11.2	269.4	11.3
9h44m8s	*qh*	6522	267.5	12.3	267.0	12.6
		6522	258.2	16.9	257.4	16.9
		6524*c*	236.6	−13.4	236.6	−13.1
		6524*b*	232.1	−13.2	232.2	−13.6
			232.5	−14.2		
			262.5	14.0		
	qo	6522	263.3	12.9	263.7	13.7
			262.1	12.7		
3083	*qi*	6519*a*	280.3	− 5.8	279.7	− 5.5
Sept. 11, '08	*qk*	6520*a*	271.0	11.2	270.6	11.5
8h41m4	*qm*	6524*a*	236.7	−13.3	236.4	−13.3
		6424*b*	232.7	−13.2	231.9	−13.7
			232.6	−14.2		
			262.0	14.1		
		6522	262.9	14.1	263.3	13.6
			261.2	14.2		
	qp	6525*a*	182.9	− 3.4	181.7	− 3.1
	qq	6522	265.4	11.7	266.6	10.9
3090	*qi*	6519*a*	280.9	− 6.3	279.3	− 5.4
Sept. 12, '08	*qk*	6520*a*	271.1	11.0	270.5	11.1
10h2m4	*qm*	6524*b*	232.9	−13.6	232.3	−13.3
	qo	6522	262.1	13.7	262.2	13.6
	qr	6525*a*	183.0	− 2.7	182.3	− 2.9
	qs	6522	266.5	11.2	266.2	11.7
3094	*qp*	6525*a*	183.5	− 2.9	182.9	− 2.7
Sept. 15, '08			233.3	−13.3		
9h31m2		6524	227.5	−13.8	227.1	−12.3
	qs	6526*a*	131.0	8.8	130.5	7.8
3100	*qr*	6525*a*	183.4	− 2.8	183.1	− 2.7
Sept. 16, '08	*qt*	6524*c*	233.8	−12.1	232.7	−11.6
11h0m	*qu*	6524	227.1	−12.0	227.0	−11.6
	qs	6526*a*	131.7	8.0	130.7	7.9
			125.9	8.8		
		6526*b*	126.5	9.5	125.9	7.8
			127.2	7.7		
3104	*qp*	6525*a*	183.9	− 2.8	183.3	− 2.6
Sept. 17, '08	*qv*	6526*a*	131.7	8.1	130.6	8.3
10h28m0	*qw*	6526*c*	125.8	9.0	125.9	8.8
	qx	6527*a*	211.5	−16.3	210.5	−16.2
	qy	6527	207.9	−17.6	207.0	−17.2
3109	*qp*	6525*a*	184.1	2.4	183.3	− 2.4
Sept. 18, '08	*qz*	6526*a*	131.9	8.8	130.7	8.5
9h30m0	*ra*	6526*b*	127.2	9.1	126.1	9.0
	rb	6529*a*	96.7	−12.3	94.9	−11.9
	rc	6529	93.1	−14.9	92.8	−13.8
3113	*qp*	6525*a*	184.3	− 2.4	183.7	− 2.4
Sept. 19, '08	*qz*	6526*a*	131.6	8.8	131.2	8.7
10h31m5	*ra*	6526*b*	127.1	8.8	127.2	8.6
	rd	6526*c*	125.9	10.1	125.7	9.9
	qx	6527*a*	97.2	−12.4	96.9	−12.3
	qy	6529	92.3	−14.6	92.9	−14.3
	re	6532*a*	93.8	5.5	94.0	5.9
	rf	6532*b*	91.8	6.8	91.7	7.0
	rg	6534*a*	76.1	16.1	75.9	16.2
3117	*rh*	6526*a*	131.3	9.1	131.0	9.1
Sept. 21, '08	*ri*	6526*b*	125.6	10.9	125.3	10.6
10h31m6	*rj*	6529*a*	97.8	−12.2	98.0	−12.3
	rk	6529*c*	77.3	16.3	77.1	16.0
	rl	6529*d*	127.8	9.0	127.6	9.1

TABLE XVIII—*Continued*

Plate Number and Date	Letter	Greenwich Number	Spectroheliograph		Greenwich	
			Longitude	Latitude	Longitude	Latitude
3121	*qx*	6529*a*	99 9	−13 1	99 0	12 5
Sept. 25, '08	*qz*	6530*a*	75 1	16 1	73 9	16 1
10^h28^m4	*rc*	6534*a*	55 8	8.4	55 3	8 3
	rd	6533	47 3	7 9	44.7	8 6
	re		45 1	10 1		
	rf	6533	45.1	11 6	42 7	11.6
	rg		42 9	9 0		
	rh	6535*a*	357 3	− 6 4	356 5	− 6 8
3124	*qx*	6529*a*	100 5	−13 4	99 4	−13 4
Sept. 26, '08		6529	97 6	−11 5	96 8	−11 7
10^h18^m5	*rc*	6534*a*	56 3	8.1	55 9	8 0
	rd	6533	47 5	7 0	47 3	7 5
	re	6533	46 0	10 0	45 3	10 1
	rf	6533	45 0	9 2	44 6	11 6
	rg	6533	45 1	11 5	44 5	8 2
		6533	43 0	9 0	42 9	11 2
		6533	43 5	10 5	42 6	9 0
	rh	6535*a*	357 0	− 6 4	357 0	− 6 2
3128	*rc*	6534*a*	58 0	7 0	56 9	7 3
Sept. 29, '08	*re*	6533	48 9	9 3	48 1	9 6
9^h11^m4	*rg*	6533	45 8	9 0	46 1	9 2
	rh	6535*a*	358 0	− 7 0	357 4	− 6 7
	ri	6537*a*	314 0	−12 6	313 5	−12 3
3132	*rc*	6534*a*	58 1	7 2	56 7	7 3
Sept. 30, '08	*re*	6533	49 8	9 7	49 3	− 9 5
9^h37^m	*rg*	6533	46.4	9.2	46 0	9 1
	rh	6535*a*	357 8	− 6.7	357.3	− 6 5
	ri	6537*a*	313 8	−12 0	313 3	−12 1
	rj	6538*a*	312 4	−12 0	325.7	−15.8
	rk	6538*b*	326 3	−15 6	323 0	−15 1
			322 5	−15 0		
3139	*rj*	6538*a*	328.6	−15 4	328 0	−15 3
Oct. 2, '08	*ri*	6537*a*	314 3	−12 0	313 7	−11.8
9^h19^m4	*rm*	6539	281.7	− 6.9	281 2	− 6.9
	rn	6539*a*	278 8	− 5.8	277.9	− 5.6
	ro	6540	271.9	11 6	271 8	11 5
3147	*rj*	6538*a*	328.9	−15 6	328 3	−15 3
Oct. 3, '08	*ri*	6537*a*	313.0	−12.3	313 6	−11 9
9^h43^m6	*rm*	6539	281.2	− 6.8	280 9	− 6 6
	rn	6539*a*	278.7	− 5 8	278 3	− 5 6
	ro	6540	272 2	11 8	271.7	11 6
3151	*ri*	6537*a*	314.2	−12 5	313 8	−12 3
Oct. 5, '08	*rm*	6539	280.8	− 7 0	280.8	− 6.7
9^h31^m6	*rn*	6539*a*	278.7	− 6.5	278 3	− 5 6
	ro	6540	272.0	11 7	271 4	12.0
3158	*ri*	6537*a*	314 3	−12 1	313 0	−12 3
Oct. 7, '08	*rn*	6539*a*	279.6	− 5.2	278 6	− 5.2
11^h40^m	*ro*	6540	272.3	12 2	271.4	12 1
3163	*rn*	6539*a*	280 3	− 5 3	279 3	− 5.2
Oct. 8, '08	*ro*	6540	272 3	12 1	271.7	12 3
9^h56^m5						
3166	*rn*	6539*a*	280 6	− 4 8	279 7	− 4 7
Oct. 9, '08	*ro*	6540	272 6	12 4	271 7	12 7
9^h52^m7	*rs*	6547*a*	185 5	6 3	184 8	6 0
3170	*ro*	6540	272 7	12 1	271 4	12 4
Oct. 10, '08	*rn*	6539*a*	282.0	− 5 0	279 9	− 4.8
9^h32^m4	*rs*	6547*a*	185 2	6 2	184 8	6 2
	rt	6549	264.8	−19 0	263 3	−18 9
	ru	6549*a*	260.6	−19.0	260 1	−18 9

TABLE XVIII—(Continued)

Plate Number and Date	Letters	Comparison Numbers	Photographic Data		Greenwich	
			Longitude	Latitude	Longitude	Latitude
3173 Oct. 12, '08 9h18m6	[illegible]	6547c	185.3	6.0	184.8	6.2
3177 Oct. 13, '08 9h38m0	*rs*	6547*a*	185.6	6.6	185.3	6.4
3195 Nov. 2, '08 11h55m6	*rr*	6558*a*	272.0	12.9	271.6	12.8
3197 Nov. 4, '08 11h05m9	[illegible] [illegible]	6558*a* 6559*a*	272.0 208.1	12.5 −14.0	271.5 208.4	12.6 −13.3
3198 Nov. 6, '08 9h48m4	[illegible] *rw* *rx* *ry*	6558*a* 6559*a* 6561 6562c	271.6 209.0 194.7 178.0	13.0 −14.0 13.9 9.3	271.6 208.8 194.3 177.5	12.7 −13.7 13.7 9.6
3213 Nov. 19, '08 11h50m0	[illegible] *sp* *sq* [illegible] *sd* *se*	6567c 6567 [illegible] 6569*a* 6569*b* 6569	77.1 75.8 73.5 65.5 60.1 61.7	3.7 5.0 4.4 10.2 12.0 10.8	76.3 75.9 65.5 59.5 61.7	3.7 4.4 9.9 11.9 10.3
3215 Nov. 20, '08 11h45m5	*rz* *sa* [illegible] *sd* *se*	6567b 6567 6569*a* 6569*b* 6569	77.7 76.9 66.4 60.3 62.0	3.4 4.7 9.8 12.0 10.8	77.0 75.8 65.2 59.5 61.0	3.4 4.9 10.1 11.9 10.7
3220 Nov. 27, '08 11h36m7	[illegible]	6574*a*	294.2	−17.8	294.9	−17.5
3223 Nov. 28, '08 11h50m9	[illegible]	6574*a*	294.0	−17.3	294.6	−17.7

SUMMARY

1. Measures of 3777 points on the calcium flocculi give the following results for the diu rnal motions (ξ) and periods (P) in mean solar days at various heliographic latitudes (ϕ).

Number	ϕ	ξ	P	Number	ϕ	ξ	P
267.....	2°.78	14°.56	24d.72	664.....	22°.20	14°.12	25d.50
540.....	7.80	14.51	24.81	274.....	27.17	13.98	25.75
842.....	12.56	14.38	25.03	107.....	32.03	13.75	26.18
1044.....	17.49	14.30	25.17	39.....	37.32	13.43	26.81

2. The results may be best represented by the formula

$$\xi = 11°.584 + 2°.976 \cos^2 \phi.$$

3. Consideration of the hemispheres separately shows higher velocities in the southern hemisphere.

4. Though the results for the later years of the series of plates indicate somewhat slower velocities than for the earlier dates, it is questionable if a variation in the rate of rotation can be considered as established.

5. The observations indicate differential motion of the flocculi about the spots, anti-cyclonic about single spots, cyclonic about the preceding member of bi-polar spots and anti-cyclonic about the following member.

6. Comparison of these observations with others by the same method shows close agreement. Comparison of the means of results by various methods shows that there is progressive increase of velocity with ascent in the solar atmosphere.

7. Figures are given for the areas covered by the flocculi. In general the zone of maximum floccula-tion coincides with the zones of maximum spottedness, and moves progressively toward the equator with the spots.

8. The positions of sun-spots are in fair agreement with the Greenwich photoheliographic results, which indicates that the method of measurement is quite as reliable as the older method of measurement.

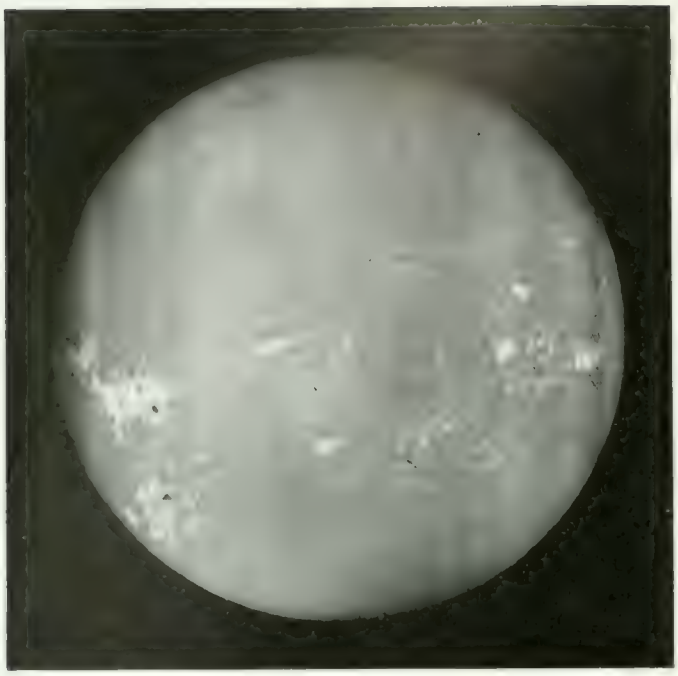
I wish to express my obligation to Professor Edwin B. Frost, who after my change of station extended to me the use of the facilities of the Yerkes Observatory that I might continue the measurement of the plates. Also I wish to express my indebtedness to Miss Laura E. Christman and to Miss Ruth D. Bannister, who assisted in many of the computations involved in the reduction of the measures to diurnal motions; and to Miss Maude Bennot for skilful assistance in the varied computations of the latter parts of this work and in its preparation in form for publication.

Dearborn Observatory
Evanston, Illinois
May 1, 1920

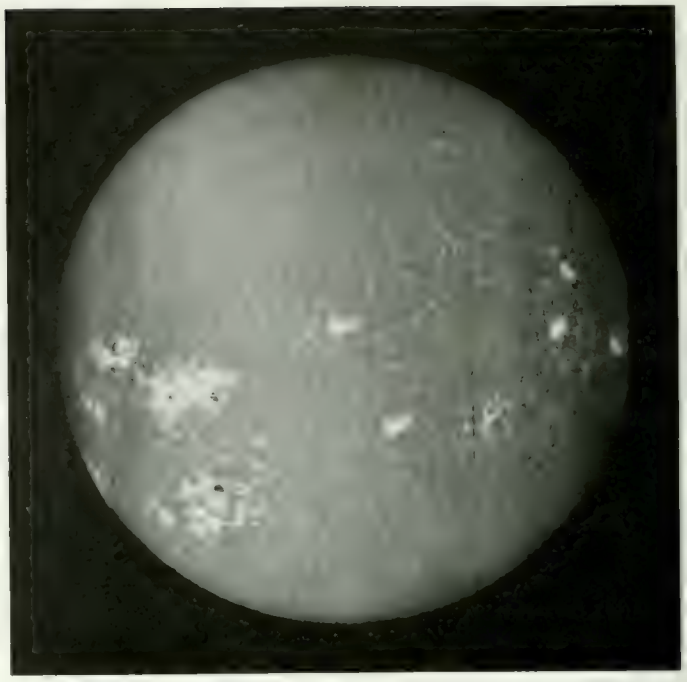
PLATE XXIV

SPECTROHELIOGRAM WITH FLOCCULI MARKED FOR MEASUREMENT

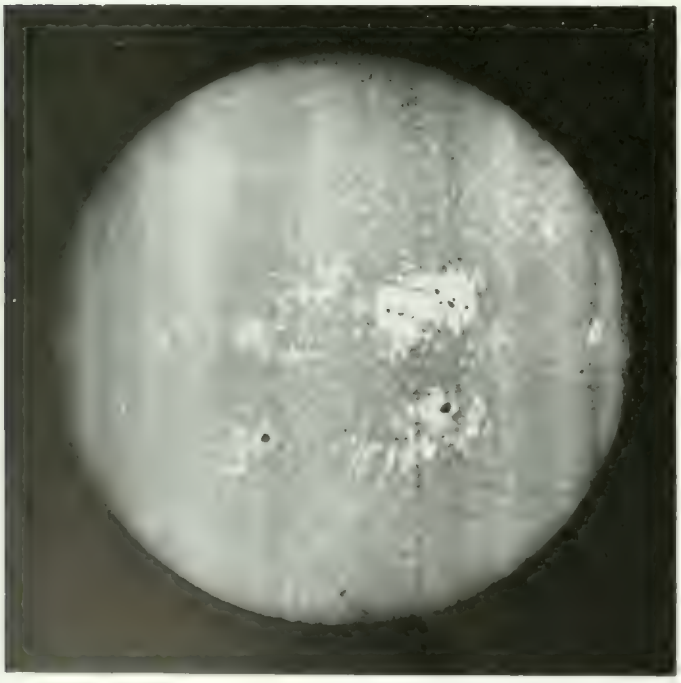
No. 3033, September 2, 1908, Fox and Abetti



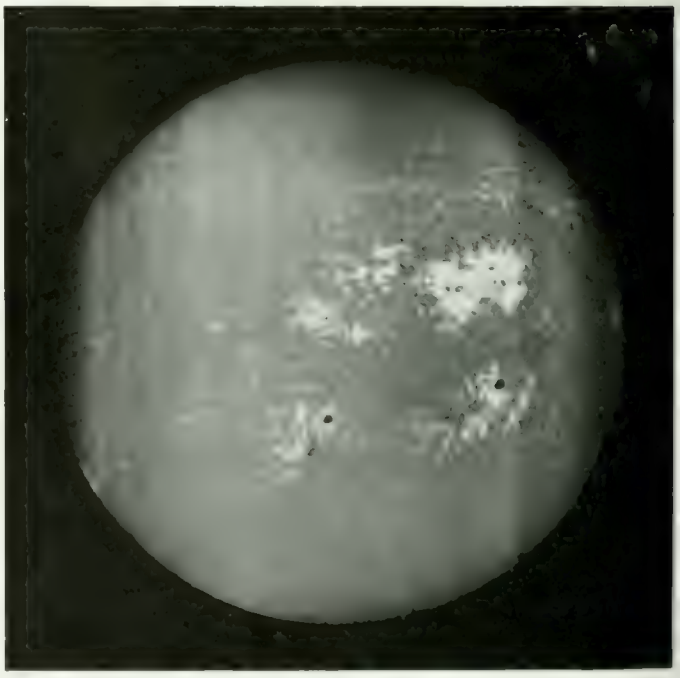
No. 2988. Aug. 27, 1908. Fox Abetti



No. 2999. Aug. 28, 1908. Fox

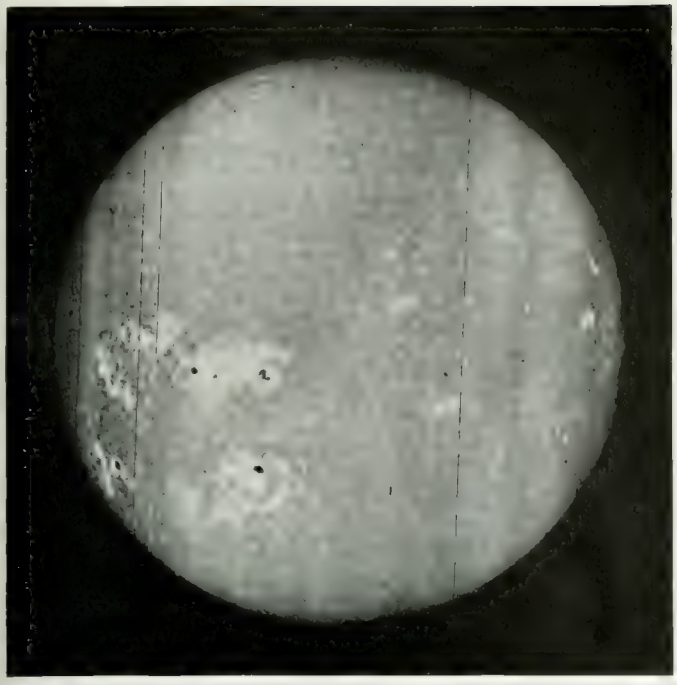


No. [illegible] Sept. 1, 1908. Fox Abetti

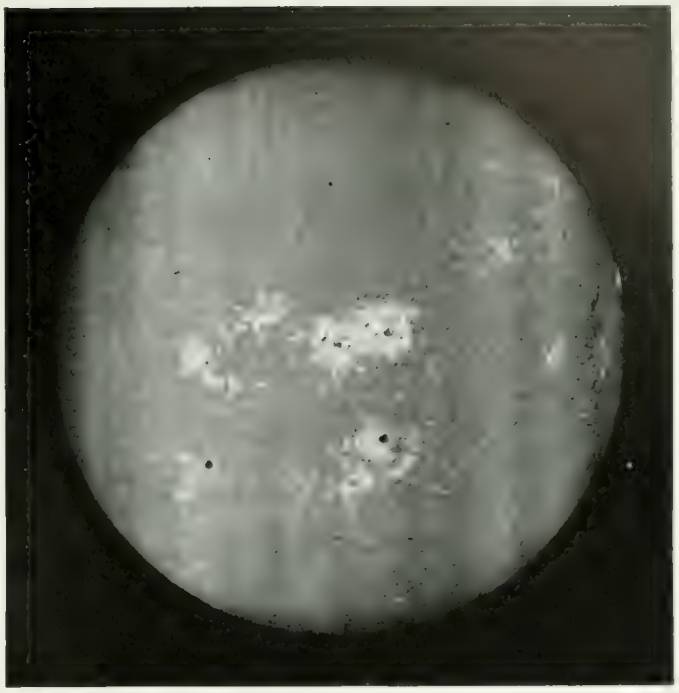


No. 3033. Sept. 2, 1908. Fox Abetti

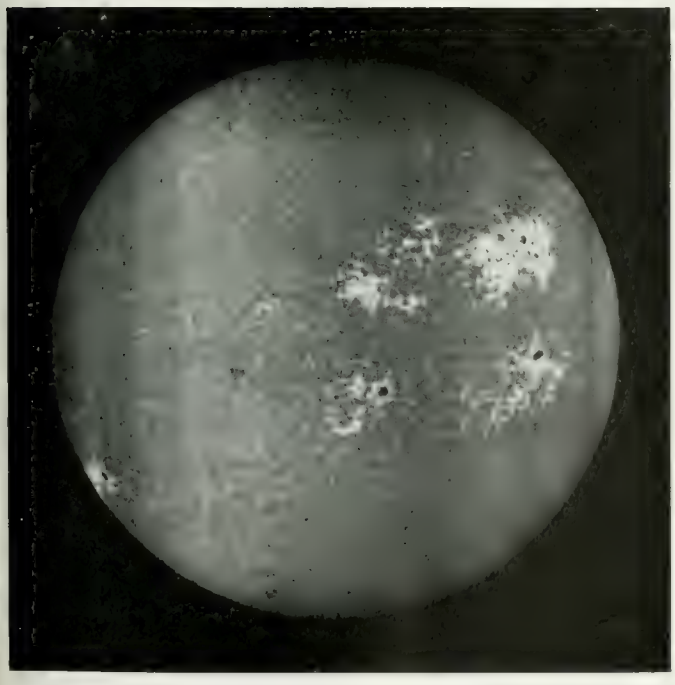
A SERIES OF SPECTROHELIOGRAMS SHOWING THE SYNODIC ROTATION OF THE SUN.



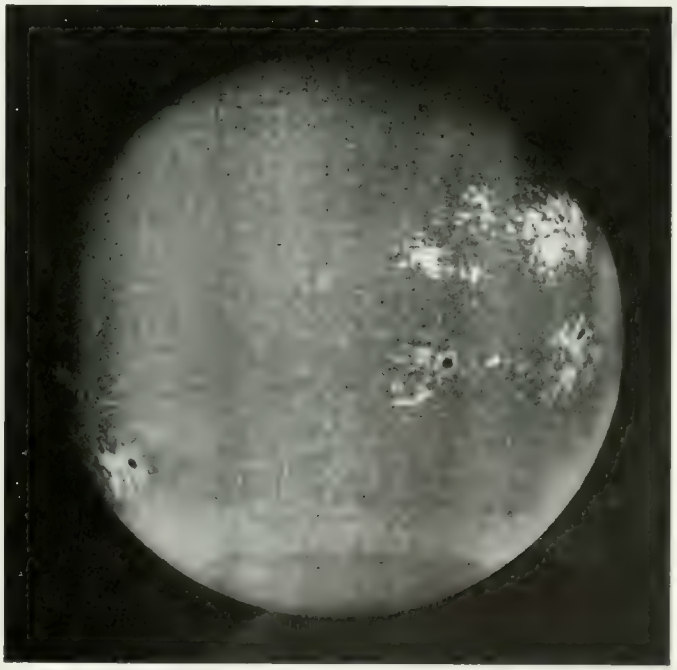
No. 3005. Aug. 29, 1908. Fox–Abetti



No. 3012. Aug. 31, 1908. Fox–Abetti



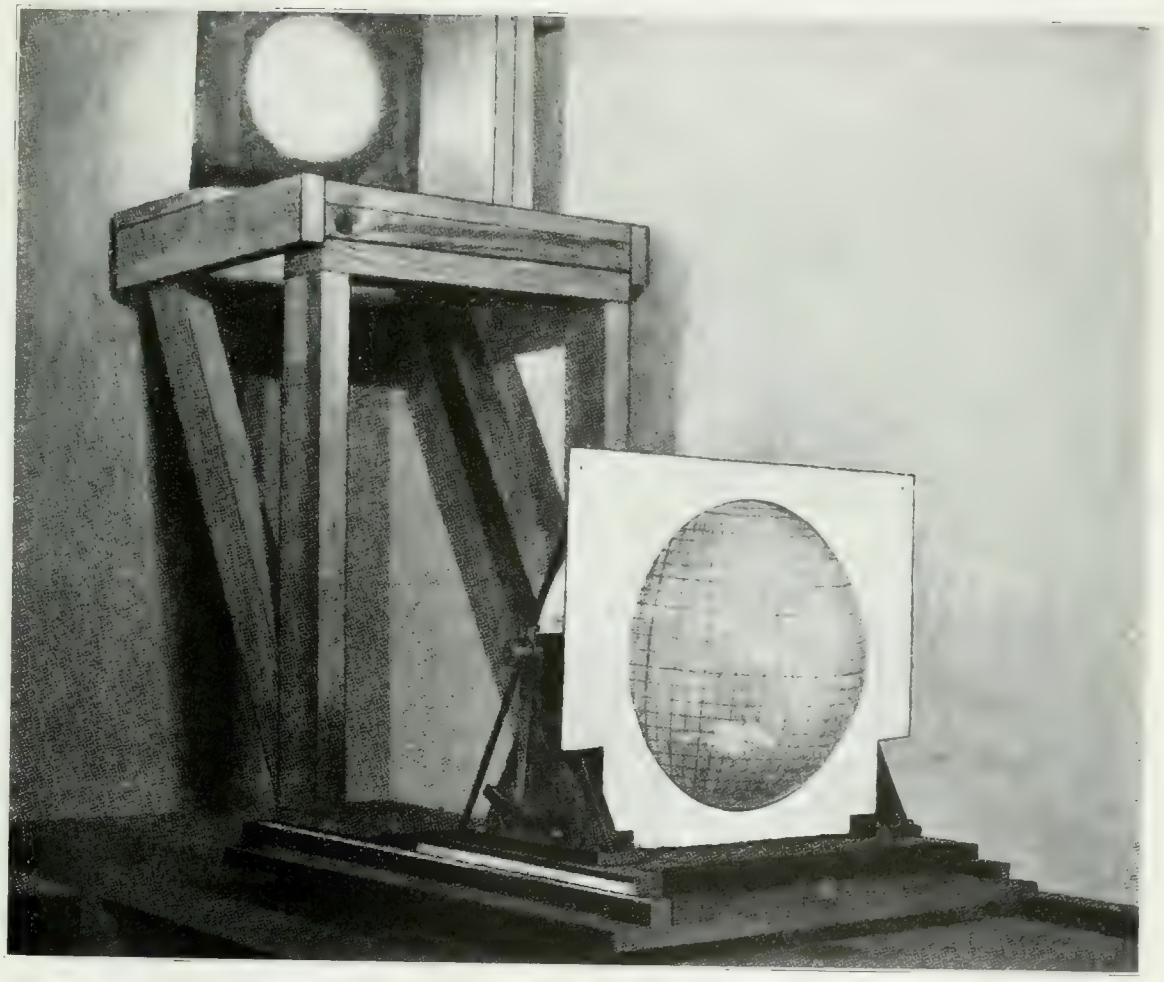
No. 3039. Sept. 3, 1908. Fox–Abetti



No. 3044. Sept. 4, 1908. Fox–Abetti

THE IMAGES ON THE ORIGINAL NEGATIVES HAVE A DIAMETER OF SEVEN INCHES

PLATE XXVI



THE RULED GLOBE WITH SPECTROHELIOGRAM PROJECTED UPON IT

THE FORMS AND MOTIONS OF THE SOLAR PROMINENCES

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CHICAGO, ILLINOIS

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PUBLICATIONS OF THE YERKES OBSERVATORY

VOLUME III PART IV
(CONCLUDING THE VOLUME)

THE FORMS AND MOTIONS OF THE SOLAR PROMINENCES

BY

EDISON PETTIT

THE UNIVERSITY OF CHICAGO PRESS
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THE FORMS AND MOTIONS OF THE SOLAR PROMINENCES[1]

By Edison Pettit

INTRODUCTION

The following work is based on a study of solar prominences photographed with the Rumford spectroheliograph of the Yerkes Observatory. The study covers both the plates already taken and a series made for special purposes.

In the beginning it was thought desirable to attempt to determine, if possible, the character of the movements and changes of form of prominences. With this in mind a preliminary survey was made of the already existing series of plates to discover any types which might prove interesting for study.

In all about four thousand plates were examined, all the interesting objects recorded, and the typical forms drawn. Very little material suitable for a study of the motions of the prominences was found, but the following types proved of interest.

1. *The "splash" type.*—This was always associated with the active type of sun-spot. No case was found not so associated. In all sixty-nine were recorded. Normally this type consists of broken spikes projecting radially from the spot, together with one or a pair of winglike prominences on either side, often raised into space, sometimes very unequal in dimensions. The prominence associated with the great spot of August, 1917, was typical of this form. As will afterward appear, the motion of these prominences, broken spikes, and loose knots of matter is into, not out from, the spot on the plates which I have measured. Occasionally a knot far removed from the spot may be found moving as though along lines of force into it. Generally, however, they are such filamentary bodies that apparently they cannot endure a long journey. The effect of "lines of force" as about a magnet is very suggestive when coupled with the fact of centripetal motion. In some cases these motions have been followed in detail, as will appear later.

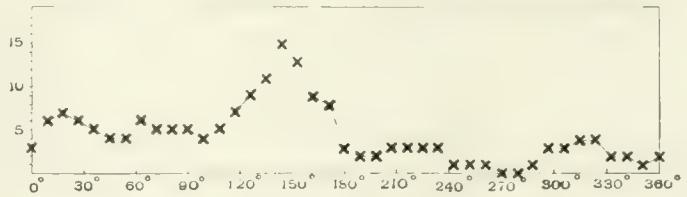


Fig. 1.—Distribution of the "splash" prominences in heliographic longitude for the period 1908 to 1920

The distribution of these splash prominences in heliographic longitude and latitude is shown in Figure 1. Obviously this is also the distribution of the great active spots associated with them over the same period, 1908–1920. Relatively few plates of the prominences were taken previously to 1908.

The distribution in latitude follows the usual sun-spot curve, but the distribution in longitude shows a sharp maximum in longitude 145°. The greater part of these prominences is found between longitudes 0° and 180°. Judging from this circumstance, this is the active hemisphere of the sun.

2. *"Tornado" or spiral prominences.*—These form a most interesting type. When perfectly developed, they are very small, generally 10″ or 15″ in diameter and 1′ or 2′ high. They appear like closely twisted rope or a fine screw. Plate XXVII shows two of these, the first taken by Slocum on October 15, 1910, and the second by the author on July 12, 1919. Such small objects are difficult to photograph since poor seeing entirely obliterates their true structure.

[1] A dissertation submitted to the Faculty of the Ogden Graduate School of Science of the University of Chicago in candidacy for the degree of Doctor of Philosophy, 1920.

Thirty cases of these tornado prominences are now available in the collection of negatives at the Yerkes Observatory. Assuming the top to be in rotation, the direction of rotation is clockwise in both hemispheres of the sun, since they all present the appearance of a right-handed screw, except in two cases where the prominence was bifurcated, the two branches rotating in opposite directions. The material was not sufficient to establish the presence or absence of lateral motion such as takes place in tornadoes on the earth.

3. *Eruptive prominences.*—This type probably needs definition. Under the classification of "eruptive prominences" have usually been placed metallic prominences, jets and prominences which rise a few seconds of arc and fall again to the chromosphere, and those which are torn apart by the action of a local attracting force. These I am not considering under this class. Only those prominences will be included which rise from the chromosphere and, projected in a more or less vertical direction, are dissipated into space at enormous altitudes. At the beginning of the work only three of these prominences had been observed in this series. One was observed by Fox on May 21, 1907; one by Slocum on March 25, 1910; and one by Lee on October 21, 1914. While it was found later that this material could be used, yet at the time this was not apparent.

THE APPARATUS

In order to follow an eruption it is necessary to develop the plates continuously. Hence every advantage must be taken of devices aimed to facilitate exposures at the telescope.

One cause of loss of time lay in the unstable prism support. This made it necessary to reset the second slit on the line after each exposure. Since the plate-holder had to be removed in order to do this, seventeen operations were required between each pair of exposures. To avoid this, a right-angled prism was inserted into the spectrum in the manner described by Hale and Ellerman in "Publications of the Yerkes Observatory," Vol. III, Part I.

Another cause of confusion lay in the lack of means of locating accurately the position of the prominence on the occulting disk. This was remedied by filing notches in the occulting disk every 10° from the east and west points. These imprinted themselves on the plate, and thus a prominence was readily located in the darkroom.

On account of the spread of the sky-spectrum, only one row of exposures could be put on a plate. To remedy this a focal-plane shutter was attached, making it possible to put two rows of exposures on a plate. By this means as many as eight or ten exposures could be put on a plate without removing it from the camera.

The driving-rod was provided with a stuffing-box and the protecting-shield raised so that it was not necessary to remove the rod for plates of the disk.

Several other modifications of the instrument were made to facilitate the exposures as much as possible and avoid any accidents which might delay the exposure or spoil the plate.

THEORY OF THE INSTRUMENT

The theory of the instrument has been given in detail in the publication referred to above. Some points, however, are of especial interest in connection with the study of the motions of the prominences. There is practically no distortion of the field, so that no correction has to be applied to observed motions on this account. Line-of-sight motions greater than about 30 km/sec. are sufficient to obliterate that part of a prominence having that velocity, from the plate.

The effect of wedge-slit was overcome by placing a small opposing lever at the end of the slit which habitually became too wide. By means of an adjustable screw this lever could be brought to bear on one jaw of the slit in such a way as to correct the wedge effect.

The error of setting the occulting disk is principally due to the fact that the telescope has a visual refractive corrective. Since the spectrohelicograph works in the H line, the sun's disk appears about 5 inches out of focus. Hence, after setting the occulting disk, about $\frac{1}{2}$ inch of the image must overlap all around

A little too much will produce serious sky fog, and too little will cut out the chromosphere. Sometimes a small drift due to clock-error may enter, but, since the whole exposure for one limb is only 99 seconds, this is not usually large enough to be noticeable.

When plates affected by faulty setting of the occulting disk are compared, several small stationary prominences are made to coincide, and the correction measured at the limb. This correction of course will always be positive.

MEASUREMENT OF THE PLATES

1. *The eruptive prominences.*—The height of an eruptive prominence at various stages of the eruption was measured by simply placing a glass scale over the plate radially to the limb and reading off the value. This was repeated with a steel millimeter scale as a check.

Generally speaking, no particular formation of a prominence can be followed throughout a series of exposures, consequently the mean height or apparent center of gravity of the object was chosen. Whenever a formation could be identified throughout a series of plates, it was used as the setting-point.

2. *Internal motions.*—The motion of knots and shreds was measured in the "blink" comparator with micrometer attached. This micrometer has two screws working cross-ruled reticles at right angles to each other. The screw value was found by comparison with the parallax machine to be $R = 0.197$ mm, and is the same for both screws.

Orientation of the plates was somewhat handicapped by the sticking of one of the plate-carriers so that it could not be rotated in position-angle. On this account orientation was accomplished as follows. The plates to be compared were placed in the plate-holders with the dust-lines parallel (nearly) to the ways, glass side out. Since the telescope is driven in declination in order to give motion to the image on the spectroheliograph, these dust-lines are arcs of hour circles, indicating N.–S. Since the position-circle of the micrometer is fixed, the zero cannot be made to coincide with the north point, and hence the error was determined. The reading for the north point was generally about 87°.5. The east point was, of course, 90° less than this. A dust-line on the movable plate (the same dust-line was generally obtainable) was then brought into coincidence with the reticle line by rotating the holder and shifting the vertical lift-screw. The two images of the chromosphere were then made to coincide and this adjustment perfected by making small prominences and lumps on the chromosphere coincide exactly. Many small prominences are generally present, which remain fixed over long periods.

The displacement of a knot or filament from an earlier plate to the next later plate was then measured in position-angle and distance. Most of the points on the plates of the prominence of May 29, 1919, were measured with the movable wire only, three settings being made on the position-circle and on each point with the screw. An opposing spring was placed on the micrometer, however, after which it was only necessary to make half the settings with the movable wire.

On account of the rapid changes in the form of the objects measured, a high degree of accuracy was not attainable. Generally a range of twenty-five to thirty-five divisions on the micrometer head was satisfactory. On the other hand, the displacements to be measured were relatively large, so that this difficulty was not a serious one.

3. *Lateral motions.*—In some cases of lateral motions, later to be described, it became desirable to measure the displacements in rectangular co-ordinates, in which both screws of the micrometer were used. The orientation was performed as before described, but the measurement proceeded as follows. In order to make each measure independent of the cumulative errors of the one preceding, each plate was compared with the same plate, which we will call the "standard plate," preferably the first plate of the series. An ink-dot was then made on the chromosphere as nearly under the midpoint of the lateral path of the prominence as possible. The reticle line parallel to the screw was then made tangent to the chromosphere at this point, and the circle read off. In all succeeding measures, this same angle, corrected for orientation, was used for the point of tangency. The origin of the fixed reticle lines was then set on this

point and the origin of the movable system was set on the prominence to be measured. The screws then read the co-ordinates. In some cases it was necessary to use the movable system for setting, as well as for measurement, on account of the limited field of the eyepiece.

PRELIMINARY OBSERVATIONAL DATA

It has already been shown by observers of eruptive prominences that the velocity of ascent increases with the height to which the prominence rises, and consequently with the time in a general way, but no one seems to have obtained the data for fixing the detailed facts of the motions. The great prominence of May 29, 1919, offered an unusual opportunity for studying the motion in detail, on account of its more leisurely ascent and the height which it reached, and the prominence of July 15 gave a means of checking the results so obtained. The general facts and observational data about these two prominences have been given in detail in the *Astrophysical Journal*, **50**, 206–219, 1919. We will confine the discussion at present to the vertical motions of eruptive prominences.

Sections 1 and 2 of Table II show the data for these prominences measured as before described, and the measures of the height as ordinates against the time as abscissas are plotted in Figure 2, Numbers 1 and 2. These results are obviously best represented by broken straight lines—in fact, remarkably well.

We must conclude that for these two prominences the motion was uniform over a period of time, after which it increased suddenly, but continued to be uniform at the greater velocity, as though an impulse had been given to it at that point. Table I exhibits a comparison[2] of the observed data for these two prominences and the data computed from the gravitational theory of projected bodies.

TABLE I

Height of Prominence above Sun	Velocity of Ascent	ΔV	Rise at This Velocity	Theoretical Maximum Height at This Velocity	Observed Duration (Const. V.)	Theoretical Duration (Dimin. V.)
The Prominence of May 29						
km.	km. sec.	km. sec.	km	km	min.	min.
150,000	5.5	5.5	50,000	83	164	0.5
200,000	14.7	9.2	119,000	665	133	1.5
319,000	27.9	13.2	91,000	3,010	57	3.6
410,000	60.0	32.1	230,000	17,059	63	9.5
The Prominence of July 15						
200,000	37.0	?	294,000	4,211	43	3.8
294,000	163.9	126.9	426,000	111,753	47	23.6

For the computation of this data the following formulae are adapted (*loc. cit.*):

$$H = s_1 - s = \frac{V_{s_1}^2}{2gR^2 - V_{s_1}}, \tag{1}$$

$$T = \frac{A\frac{\pi}{2} - AB + C}{D}, \tag{2}$$

$$t = \frac{A \sin^{-1}\left[\frac{2}{\quad}\right] - AB + C - V_{s_1}(s_1 - s)^2}{D}, \tag{3}$$

[2] *Astrophysical Journal*, 50, 214, 1919.

where

$$A=\frac{s_1}{2}, \qquad B=\sin^{-1}\left[\frac{2s_0-s_1}{s_1}\right], \qquad C=\sqrt{s_1s_0-s_0^2}, \qquad D=R\sqrt{\frac{2g}{s_1}}.$$

g = acceleration of a falling body at the sun's surface (0.27 km/sec.)
H = "theoretical maximum height attained" measured from sun's surface
R = radius of the sun (695,553 km)
s = distance at any instant from the sun's center
s_0 = distance from the sun's center at the time when the velocity V_0 begins (measured from the break in the graph of the heights of the prominence)
s_1 = "theoretical maximum height attained" measured from the sun's center
T = time required to attain height H ("theoretical duration")
t = time required to attain distance s from sun's center
V_0 = "velocity" observed, measured from the plot

In these formulae the positive direction of the axes is taken upward and angles are in radians. It will be noted that the gravitational theory is not sufficient even to approximate the observed facts over a short period.

The prominence of September 8, 1919, and the one observed by Lee on February 19, 1920, also show the characteristics of motion found in those of May 29 and July 15, 1919.

THE COLLECTED OBSERVATIONAL DATA

As it appeared that this peculiarity of motion of eruptive prominences might be characteristic of all eruptions, an investigation of all available published data was made to determine the facts of the case. All cases of observed eruptions where four or more measures of the height were obtained during the ascent were collected, and plotted uniformly with G.M.T. as abscissas and the height in thousand kilometers as ordinates. Generally the data gave local or standard time of observation and the height in seconds of arc. These were converted by the proper formulae. In some cases of spectroheliographic observation the plates or prints were remeasured, for reasons stated in the appended notes. Eighteen cases besides those already mentioned were found, making in all, at present, twenty-four cases of eruptive prominences for which the data are sufficient for the study of their motion. Of these, eleven are spectroheliographic results.

DISCUSSION OF THE COLLECTED OBSERVATIONAL DATA

From an examination of the plots of the observations given in Figures 2–5, one can hardly avoid the conclusion that in every case so far observed the motion of ascent obeys the principle found in the prominence of May 29, 1919, namely, that the motion is always uniform, affected at intervals by sudden increases, as though an impulse had been given to the prominence.

The validity of this method of treating the observations can hardly be questioned, for each observation itself is not definitive, and in this kind of measurement is subject to considerable error as compared, say, to measurements for positions of stars. The actual velocities attained, then, are represented by the slopes of these straight lines, and not by $\delta h/\delta t$ between successive observations. Indeed, two successive velocities might be 60 km/sec. and −10 km/sec. and still the plotted observations could fall satisfactorily near the mean line, if δt were not too great. Take, for example, the prominence of September 19, 1893,[3] for which Fényi gives the velocities reduced from $\delta h/\delta t$, shown in Table III on page 212.

To find any law of motion applicable to these data would be quite discouraging, but the difficulty lies in the treatment of single observations as definitive, which is far from the case. Referring to the graph for this prominence (Fig. 4, No. 17), it will be seen how well the observations of this prominence follow the

[3] *L'Astronomie*, **13**, 173, 1894.

TABLE II

COLLECTED DATA ON ALL PUBLISHED MEASURES OF ERUPTIVE PROMINENCES

Identity and Remarks	G.M.T. of Observation	Height in Thousand Kilometers
1. May 29, 1919. Observed by Pettit at the Yerkes Observatory. Spectroheliograph. *Astrophysical Journal*, **50**, 209, 1919. Mean height of the floating cloud is given. V = 5.5, 14.7, 27.9, 60.0 km/sec.	1 17 09	150
	36 25	150
	41 16	150
	51 49	153
	2 35 21	163
	41 44	170
	49 39	170
	56 56	175
	4 09 40	175
	19 32	200
	31 03	210
	38 12	220
	46 49	225
	5 13 59	250
	32 41	265
	40 39	275
	56 36	285
	6 14 12	305
	23 34	310
	32 18	322
	42 00	335
	53 22	360
	7 08 49	388
	19 31	410
	57 22	545
	8 23 29	640
2. July 15, 1919. Observed by Pettit at the Yerkes Observatory. Spectroheliograph. *Astrophysical Journal*, 50, 211, 1919. Settings were made on a ropelike structure enduring throughout the eruption. V = 37.0, 163.9 km/sec.	3 08 02	200
	28 48	250
	35 49	263
	43 59	278
	51 56	315
	4 01 11	400
	07 19	460
	15 57	548
	23 39	620
	33 57	720
3. September 8, 1919. Observed by Pettit at the Yerkes Observatory. Spectroheliograph. Not published. Settings made on the center of the cloudlike head. V = 3.7, 25.6 km/sec.	2 35 32	85
	3 01 52	93
	35 59	95
	38 37	97
	46 07	101
	46 42	103
	4 21 22	116
	34 12	128
	37 12	131
	6 16 10	286
	23 30	301
	41 10	321
	50 21	348
September 8, 1919, continued. Settings made on a condensation near the middle of the prominence. V = 25.0 km/sec.	6 16 10	150
	24 12	160
	41 10	193
	50 10	210
	7 01 07	225
	08 05	230
4. February 19, 1920. Observed by Lee at the Yerkes Observatory. Spectroheliograph. Not published. Centers of the cloud regarded. V = 10.6, 18.6, 41.7 km/sec.	3 58 40	110
	4 48 00	144
	56 30	148
	58 20	152
	5 22 50	171
	24 25	175
	31 50	186
	34 50	186
	56 55	205
	58 50	209
	7 24 15	311
4. Feb. 19, 1920—*Continued*	7 25 35	319
	33 40	322
	35 11	326
	55 25	334
	57 01	341
	8 15 30	387
	18 50	387
5. October 21, 1914. Observed by Lee at the Yerkes Observatory. Spectroheliograph. No measures published. *Astrophysical Journal*, **41**, 168, 1915. V = 6.7, 22.0, 42.8 km/sec.	3 17	106
	54.5	123
	56.5	129
	4 17	144
	18.7	145
	49.2	186
	50.7	189
	57.5	199
	58.7	204
	5 05.7	220
	07.5	234
	33.5	293
	35.5	292
6. March 25, 1910. Observed by Slocum at the Yerkes Observatory. Spectroheliograph. *Astrophysical Journal*, **32**, 128, 1910. On account of the prominence being cut off in two exposures, the plates were remeasured, using a point lower down. V = 6.1, 31.4, 53.6 km/sec.	2 54.9	38
	4 14.7	53
	16.7	68
	56.1	103
	57.9	148
	5 10.6	174
	43.0	276
	45.0	287
	55.4	295
	57.7	295
7. May 21, 1907. Observed by Fox at the Yerkes Observatory. Spectroheliograph. *Astrophysical Journal*, **26**, 155, 1907. V = 7.5, 37.5, 64.2 km/sec.	4 02	169
	52	190
	5 01	206
	35	287
	37	294
	43	317
	44	272
	44.5	272
	52	307
	53	305
	55	311
	57	301
	59	303
8. February 18, 1908. Observed by Evershed at the Kodaikanal Observatory. Spectroheliograph. *Astrophysical Journal*, **28**, 79, 1908. See also *Bulletins of the Kodaikanal Observatory*, **2**. Only group measures are given. Halftone cuts were remeasured in order to give more points. V = 3.3, 29.3 km/sec.	2 53	58
	4 08	69
	24	77
	31	77
	5 35	96
	43	96
	9 00	113
	06	113
	10 35	144
	40	154
	11 41	234
	47	261
	12 02	290
	11	301
9. May 26, 1916. Observed by Evershed at the Kodaikanal Observatory. Spectroheliograph. *Bull. of the Kodaikanal Observatory*, 3, No. 55, Plate IV. A secondary eruption from the crest of the prominence made it necessary	2 36 12	102
	51 47	166
	06 29	220
	16 25	322
	20 40	372
	26 40	440

TABLE II—*Continued*

Identity and Remarks	G.M.T. of Observation	Height in Thousand Kilometers
9. May 26 1916—*Continued* to remeasure the cuts in order to insure continuity of the point measured. $V = 64.2, 191.7, 316.6$ km/sec.	3h33m19s	524
	39 34	643
10. May 31, 1894. Observed by Deslandres at the Paris Observatory. Spectroheliograph. *Comptes Rendus*, **124,** 172, 1894. $V = 13.8, 54.4$ km/sec.	1 55	103
	4 18	220
	51	323
	5 31	458
11. March 25, 1895. Observed by Hale and Ellerman at the Kenwood Observatory. Spectroheliograph. *Astrophysical Journal*, **1,** 433, 1895. $V = 49.0, 119.0, 202.0$ km/sec.	*15 40	87
	16 24	216
	30	259
	*36	303
	48	450
12. August 16, 1885. Observed by Trouvelot at the Meudon Observatory. Visual. *Comptes Rendus*, **101,** 475, 1885. $V = 53.3, 89.2$ km/sec.	9 16	172
	10 21	213
	37	264
	38	278
	42	290
	47	298
	53	320
	58	341
	11 00	352
	02	361
	04	373
	11	416
13. September 6, 1888. Observed by Fényi at the Haynald Observatory (Kalocsa). Visual. *Pub. of the Haynald Observatory*, **1,** 119, 1888. $V = 2.2, 83.3, 175.5$ km/sec.	4 25	15
	50	18
	52	33
	55	43
	59	68
	5 03	110
14. October 6, 1890. Observed by Fényi at the Haynald Observatory. Visual. *Pub. of the Haynald Observatory*, **1,** 131, 1888; and *Comptes Rendus*, **111,** 725, 1890. $V = 40.0, 70.0, 223.3, (56.7)$ km/sec.	0 02	40
	07	50
	10 20	66
	12 50	76
	19 25	100
	†21	123
	23	148
	27	206
	29 40	225
	33	236
15. May 5, 1892. Observed by Fényi at the Haynald Observatory. Visual. *Pub. of the Haynald Observatory*, **2,** 131, 1892. $V = 81.7, 233.3$ km/sec.	10 39	102
	11 01	209
	02 45	231
	05 09	269
	. . . . .	275
	09	295
	. . . . .	299
	. . . . .	350
	13 25	388
16. September 20, 1893. Observed by Fényi at the Haynald Observatory. Visual. *L'Astronomie*, **13,** 174, 1894. *Mem. Spett. Ital.*, **23,** 30, 1894. $V = 400$ km/sec.	9 08 13	353
	09 04	367
	09 57	390
	10 52	414
	11 51	435
	12 56	446
	14 07	482
	15 18	501

Identity and Remarks	G.M.T. of Observation	Height in Thousand Kilometers
17. September 19, 1893. Observed by Fényi at the Haynald Observatory. Visual. *L'Astronomie*, **13,** 173, 1894. *Mem. Spett. Ital.*, **23,** 29, 1894. $V = 119.4, 375.0, (250.0)$ km/sec.	2h21m05s	268
	(21 51)	(256)
	22 37	278
	23 36	286
	24 25	296
	25 19	319
	26 15	338
	27 16	344
	28 23	362
18. December 24, 1894. Observed by Fényi at the Haynald Observatory. Visual. *Astrophysical Journal*, **1,** 213, 1894. $V = 15.5, 144, 144$ km/sec.	9 15 00	88
	10 17 59	151
	18 29	148
	18 59	156
	19 30	160
	20 01	150
	20 33	154
	33 45	266
	34 31	276
	35 20	288
	36 09	297
	37 03	309
	41 33	369
	42 45	364
	†48	388
	49 23	404
	†52 04	445
	55 21	470
	11 06 31	286
	09 57	317
	11 20	330
	12 44	282
	24 51	255
	. . . . .	222
	38 04	193
	38 57	193
	39 24	107
19. September 30, 1895. Observed by Fényi at the Haynald Observatory. Visual. *Astrophysical Journal*, **3,** 193, 1896. $V = 400$ km/sec.	‡10 00	43
	‡11	174
	14 22	342
	15 11	371
	16 03	380
	16 57	407
	17 50	430
	19 02	446
	20 11	498
	§21 00	357
	29 20	380
	30 13	388
	46 39	142
20. June 1, 1900. Observed by Fényi at the Haynald Observatory. Visual. *Astrophysical Journal*, **12,** 215, 1900. Height of the vertex and base of the floating cloud were observed. Mean height is given here. $V = 242$ km/sec.	2 14 08	159
	14 41	177
	15 16	177
	15 52	186
	16 29	203
	17 16	213
	18 04	225
	‖18 55	227
21. August 24, 1893. Observed by Sakora at the Charkow Observatory. Visual. *Mem. Spett. Ital.*, **23,** 201, 1894. $V = 22.5$ km/sec.	21 19	10
	22 01	64
	20	95
	23 21	79

* Visual estimate.

† Time uncertain.

‡ Micrometer measure. Probably affected by distortion.

§ Uncertain.

‖ "Approaching dissolution" noted here.

TABLE II—*Continued*

Identity and Remarks	G.M.T. of Observation	Height in Thousand Kilometers
	8h10m00s	94
	40	104
	9 13	113
	54	124
	10 40	142
22. November 16, 1892. Observed by Tacchini at Rome. Visual. *Mem. Spett. Ital.*, **22**, 9, 1893.	11 05	152
	50	201
	12 03	288
	10	
V=4.4, 6.6, 28.3, 57.2, 115.0 km/sec.	14	247
	29	307
	37	332
	42	367
	43	382
	44	382
	45	382
23. June 11, 1895. Observed by Coit at the Boston University Observatory. Visual.	7 17	54
	36	63
	55 03	86
23. June 11, 1895—*Continued*	7h59m18s	122
Astronomical Journal, **15**,	8 00 18	131
112, 1895. Coit used the	01 18	145
mean value of the sun's apparent diameter in reducing	03 03	154
	06 58	179
the observations; the values	12 00	185
given here have been reduced	14 00	195
using the *Ephemeris* value	17 18	203
for the date.	19 28	212
V=7.8, 136.1, 58.7 km/sec.	27	77
	47	59
24. May 23, 1915. Observed by Evershed at the Kodaikanal Observatory. Spectroheliograph. *Mem. Kod. Observatory*, **1**, Part II, 1917. No measures published.	3 04	143
	18	206
	52	348
V=70.8 km/sec.		

law of uniform motion affected by sudden increases of velocity. Velocity 3, in Table III, was computed on a break in the line, and so does not agree with any on the list. Velocities 5 and 6 are doubtless discordant on account of fading of the crest of the prominence. Applying the slope of the line, the actual velocities are only three in number, viz., 119, 375, and (250) km/sec.

TABLE III

No.	km/sec.	No.	km/sec.
1	114.6	5	339.6
2	126.1	6	103.9
3	214.0	7	249.1
4	406.0		

Pringsheim[4] uses Fényi's published velocities of the prominence observed on October 6, 1890, to substantiate the statement that the velocities of eruptive prominences "undergo very irregular changes in direction and value." An examination of the plot (Fig. 4, No. 14) reveals no such irregularity, with the possible exception of the last two measures which are doubtless affected by fading.

This fading of the prominence is one of several phenomena accompanying an eruption which, in visual work, may produce a large uncertainty in the interpretation of the velocities at the end of the ascent. The rapidity of the fading has been noted by many observers. Thus Fényi says, speaking about the prominence of June 1, 1900 (for graph see Fig. 5, No. 20):

> Approaching dissolution was noted during the last transit; the smaller portions were invisible, and the larger somewhat faint and diffuse, unless probably this was the effect of a temporary haziness of the sky. Three minutes later the entire brilliant prominence had disappeared; no trace could any longer be seen, even far above the chromosphere.[5]

The same circumstances have been noted frequently by observers with the spectroheliograph. Generally, it seems, the duration of the fading is only a matter of a few minutes.

That a prominence may fade in part and the remainder continue to ascend is well shown in the prominence of December 24, 1894, observed by Fényi (Fig. 4, No. 18). Here, evidently, the detached portion of

[4] [illegible], 12, 217, 1900.

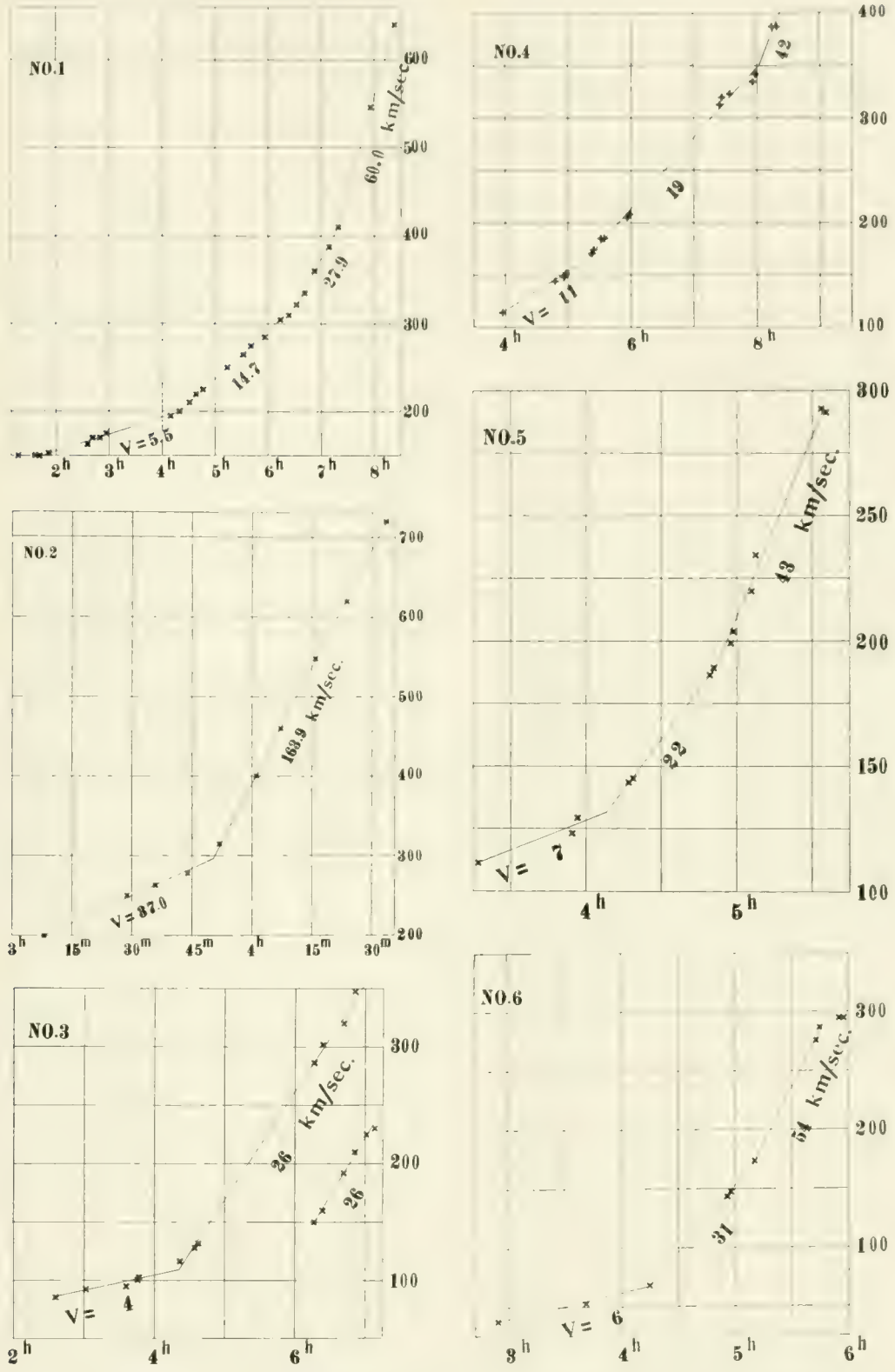


FIG. 2.—Motions of the eruptive prominences of (No. 1) May 29, 1919; (No. 2) July 15, 1919; (No. 3) September 8, 1919; (No. 4) February 19, 1920; (No. 5) October 21, 1914; (No. 6) March 25, 1910. The abscissas are the times of observation (G.M.T.), and the ordinates are the heights of the prominence in thousand kilometers.

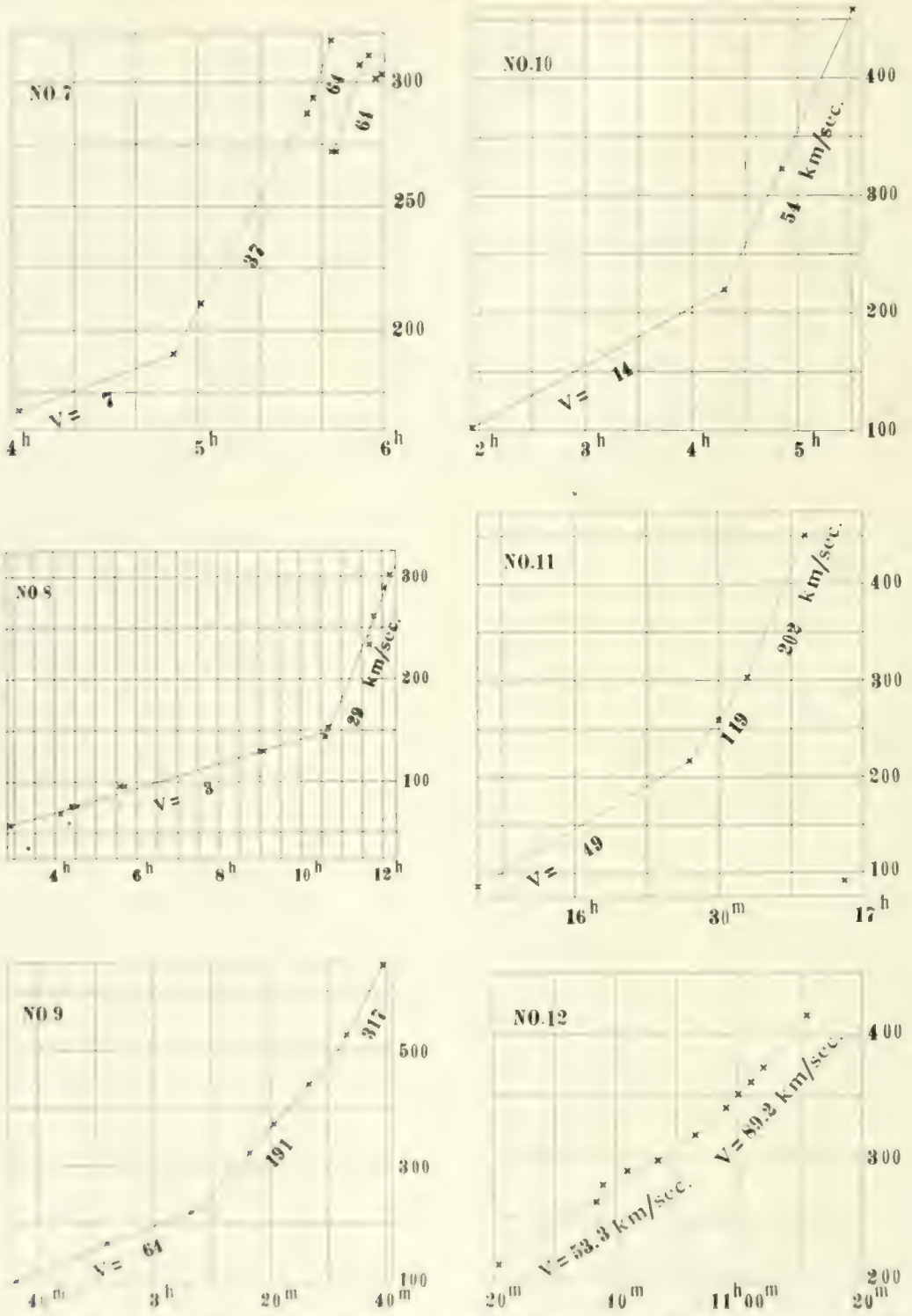


FIG. 3.—Motions of the eruptive prominences of (No. 7) May 21, 1907; (No. 8) February 18, 1908; (No. 9) May 26, 1916; (No. 10) May 31, 1894; (No. 11) March 25, 1895; (No. 12) August 16, 1885. The abscissas are the times of observation (G.M.T.), and the ordinates are the heights of the prominence in thousand kilometers.

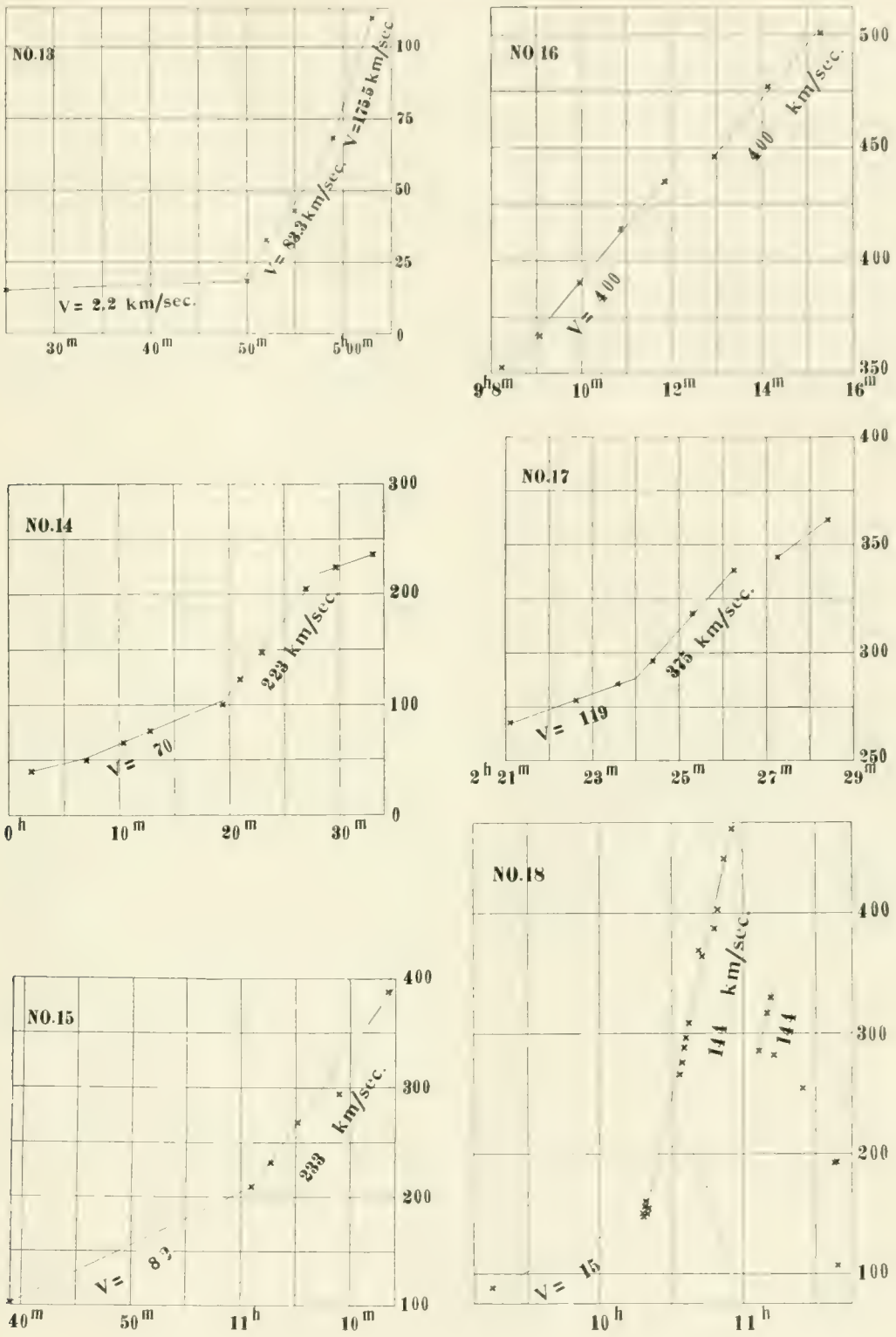


FIG. 4.—Motions of the eruptive prominences of (No. 13) September 6, 1888; (No. 14) October 6, 1890; (No. 15) May 5, 1892; (No. 16) September 20, 1893; (No. 17) September 19, 1893; (No. 18) December 24, 1894. The abscissas are the times of observation (G.M.T.), and the ordinates are the heights of the prominence in thousand kilometers.

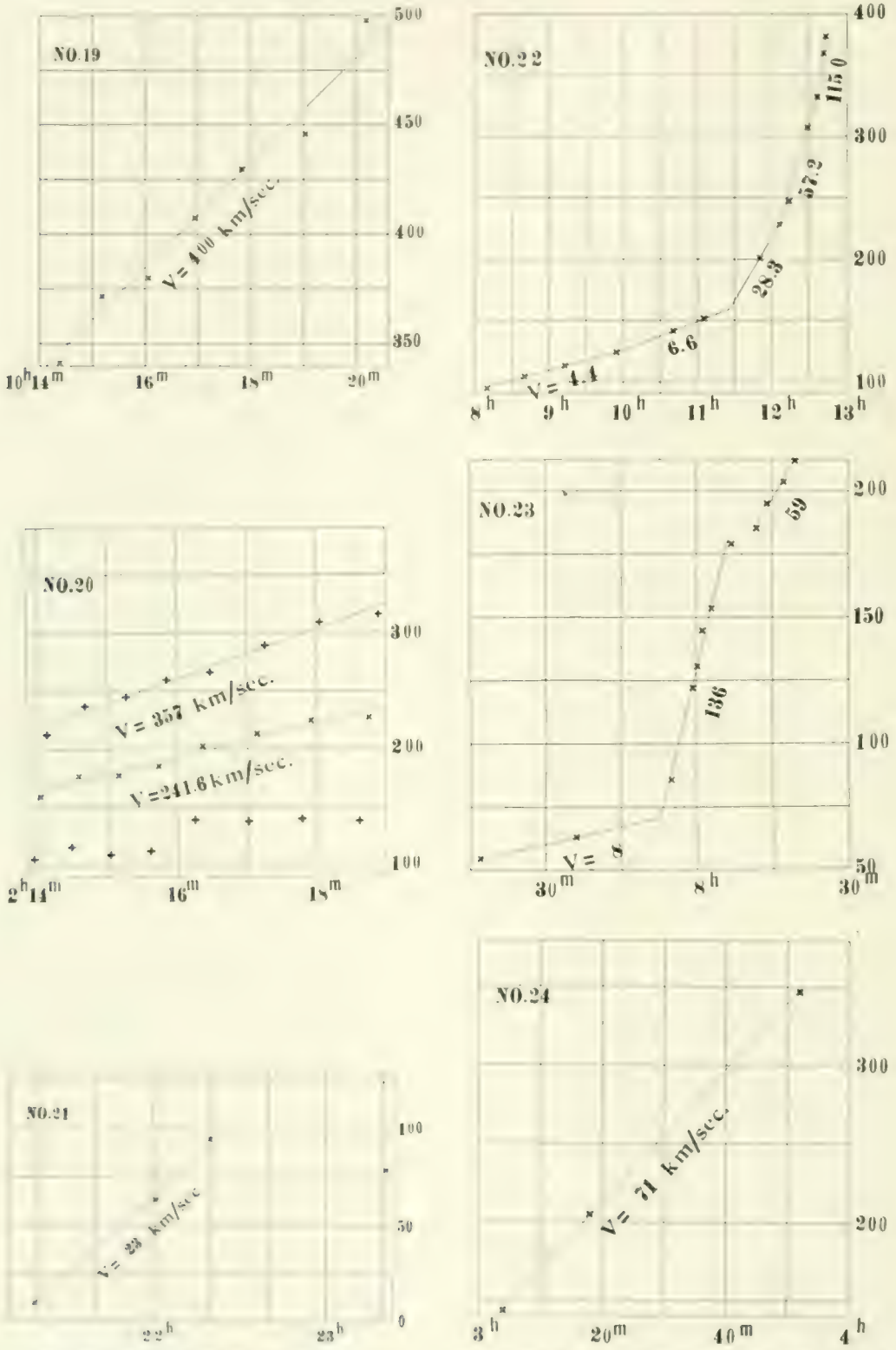


FIG. 7.—Motions of the eruptive prominences of No. 19, September 30, 1895; [No. 20, June 1, 1896]; No. 21, August 24, 1896; No. 22, November 16, 1892; No. 23, June 11, 1895; [No. 24, May 23, 1901]. The numbers are the hours of observation (G.M.T.) and the ordinates are the heights of the prominences in thousand kilometers.

the curve is a point lower down, rising after the prominence has been decapitated by fading. Hence the duration of fading must have been less than 10 minutes—the time between the observations on the two portions of the plot. The same phenomenon is apparent in his observations of the prominence of September 20, 1893 (Fig. 4, No. 16). Fox's prominence observed with the spectroheliograph on May 21, 1907 (Fig. 3, No. 7), is also of this class.

Fényi's prominences of October 6, 1890, and September 19, 1893 (Fig. 4, Nos. 14 and 17), seem to show indications of negative impulse or secondary eruption at the end of the ascent. Coit's prominence of June 11, 1895 (Fig. 5, No. 23), is the finest example of this class of phenomena. The nature of the action at the end of the eruption just after dissolution sets in is very uncertain and difficult to interpret without the aid of photography.

The effect of a secondary eruption is seen in Evershed's prominence of May 26, 1916, where a fountain of matter is ejected from the principal body after the prominence has reached a considerable height.

In his analysis of his observations on the prominence of June 1, 1900, Fényi gives the following data on the velocity of the crest:

TABLE IV

km/sec.	km/sec
546	471
231	423
371	138
187	

From the plot (Fig. 5, No. 20) it will be seen that a straight line represents both the mean and the crest velocities very satisfactorily.

Fényi says:

> I must state in regard to the velocities of ascent in the fourth column that no safe conclusions can be drawn from their differences, as they are the result of the uncertainty of the individual measures from which the figures were calculated. On trying to smooth out the data graphically I found that, if corrections of at most 0.6 sec. are applied to the time of transit, an entirely uniform ascent with constant velocity is obtained.
>
> Such corrections are entirely justified by numerous transits of prominences, for it is not unusual for a single measure to differ from the mean of many transits by more than 0.5 sec. The assumption of uniform motion is unjustified, however, as the prominence is without doubt under the influence of gravity, and it must therefore sink at the time it is rising, unless it is impelled upward by some quite problematical continuous force. I have reduced the observed altitudes on the assumption of constant gravity with an acceleration of 270 meters, and again sought to smooth them out graphically. I found that the observed times of transit would require a correction of 0.7 sec. in only one case in order to be in full agreement with this assumption. Hence it appears that the above observations, despite the capricious ascent, are by no means inconsistent with the assumption that the prominence is a mass of hydrogen projected from the sun, which rises above the chromosphere with the velocity of empty space and is under the influence of gravity alone.[6]

Now the velocity is 354 km/sec. at a height of 218,000 km above the sun. This is over half the parabolic velocity, and since the observations cover a period of only 5 minutes, the straight line approximates the parabola very closely over this short interval. He admits that the straight line represents the observations just a little better, however. Had the same reasoning been applied to a more slowly moving or longer enduring prominence the case would have been more evident.

Fényi's prominence of December 24, 1894, the duration of which was two hours, is one of the finer examples exhibiting the characteristics of uniform motion broken by impulses. When we take the prominence at the first break, and apply the general gravitational formulae of page 208 (Nos. 1, 2, and 3) we have:

$s_0 = 845{,}553$ km	$T = 14^m 28^s$	$C = 227{,}469$
$V_0 = 144.4$ km/sec.	$A = 453{,}373$	$D = 536.76$
$H = 61{,}193$ km	$B = 1.0450$	$s_1 = 906{,}746$ km

[6] *Astrophysical Journal*, **12**, 216, 1900.

The following table was then computed from formula 3.

TABLE V

s	t	s	t
km		km	
845,553.....	0m00s	906,746....	14m28s
865,553.....	2 33	795,553....	14 51
885,553.....	5 53		

Here t is computed from the time the velocity began, namely, 10^h19^m G.M.T., and s from the center of the sun. From this data the dotted portion of the curve was plotted (Fig. 4, No. 18). One would hardly say that this prominence has been rising "with the velocity of empty space and under gravity alone." In fact, with many of the prominences it is impossible to represent the curve under gravity on the scale on which the observations are plotted, on account of the small dimensions of the parabola.

LATERAL MOTIONS

I am here using the term "lateral motions" to mean motions of prominences which rise from the sun's surface, and, passing over a trajectory, generally re-enter the chromosphere. Unfortunately, the observational data with detailed measures are rather scanty. None are to be found in the literature, perhaps on account of the relatively small size of the objects involved. Sufficient data were secured in only two cases to give anything like a life-history of such phenomena. Like the great eruptions, these laterally moving prominences endure only a short period of time with high velocities; but, unlike them, they disappear, apparently, not by fading away, but by bodily re-entering the chromosphere—like water poured into a pond. A number of others have been observed with the spectroheliograph, and while the data are not sufficient to warrant analysis here, the description of the two given is typical of all.

1. *The "sigma" prominence of September 23, 1919.*—This prominence (see Plate XXVIII) as photographed in the early morning would have been classified as quiescent. A small streamer leaving one side (exposure 1) entered the chromosphere at a point about 100,000 km distant. Toward noon the whole prominence seemed to rise slightly and lean violently toward the point above indicated, as if it were being torn from its anchorage in the chromosphere. By half-past one the number of streamers had increased to five, and the whole body began to disintegrate. The crest was torn away and, traversing a trajectory, entered the chromosphere 225,000 km from the starting-point for the particular knot measured. This knot, which was the most brilliant part, was always connected to the point of attraction by long streamers which themselves followed a somewhat shorter orbit of similar shape. The action was much like the cracking of a whip, the end swinging out and going beyond the path followed by the flexible body. Thirteen exposures (Plate XXVIII, Nos. 3–15), during the principal part of the action, were measured in X and Y co-ordinates with the "blink" comparator and micrometer. These measures were reduced to thousand kilometers and plotted to scale (Fig. 6, No. 1). The direction of the motion was toward the left, as indicated by the arrow. The first three observations (at the right) were made while the knot was still attached to the prominence, and are indicated by the dotted line. Probably they are not comparable with the others since the knot was not in free motion at the time.

While the trajectory is fairly represented by the ellipse, yet perhaps it is as well represented by a modified form of curve.

The plotted points were projected on this mean line of motion and their distances from the first point, which represents the beginning of the motion, were measured off along the curve. These measures were then plotted against the time of observation as before in the study of the great eruptions. Plot 2 of Figure 6 represents this curve. It is very apparent that the law of motion here is the same as that followed by the eruptive prominences already discussed, and that the velocity (75.8 km/sec.) is of the same order.

2. *The "rocket" prominence of October 6, 1919.*—The early history of this prominence is very similar to that already described for the "sigma" prominence until the motion began. A piece was torn off bodily from the prominence as the other quarter the streamers had, without any visible connection with the chromo-

sphere, traversed a trajectory like a stone thrown from a catapult, and entered the chromosphere 150,000 km away. Plate XXIX shows twelve exposures during the period of activity.

Eleven plates were measured in X and Y co-ordinates and plotted to scale (Fig. 6, No. 3). The astonishing thing is that the trajectory is a circle of radius 73,500 km from a point 17,000 km above the chromosphere. The center of the circle is the empty cross. The arrow represents the direction of motion.

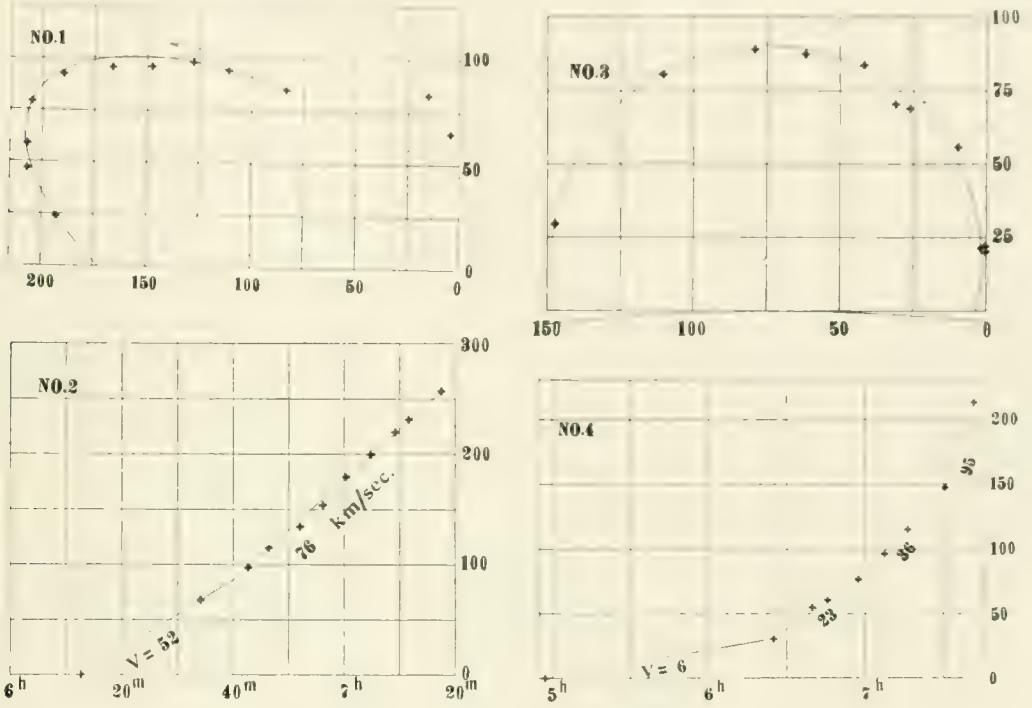


FIG. 6.—Trajectories of the prominences of (No. 1) September 23, 1919; (No. 3) October 6, 1919. Motions of the prominences of (No. 2) September 23, 1919; (No. 4) October 6, 1919. The abscissas of Nos. 1 and 3 are in units of thousand kilometers, and of Nos. 2 and 4 are times of observation (G.M.T.). The ordinates are in units of thousand kilometers.

The plotted points were projected on the circle and their distances from the beginning of the motion measured as before. The plot of these measures against the times of observation is given in plot 4, Figure 6. The data in this case are not conclusive, since a smooth curve represents the measures about as well as the broken line. About double the number of observations would be required to decide the question. Table VI gives the measures for these two prominences.

TABLE VI

	Exposed at G.M.T.	In Units of 1000 km		
		X	Y	Distance Traversed
1. September 23, 1919. Observed by Pettit. Spectroheliograph. The "sigma" prominence.	6h00m52s	0.0	58.5	.....
	04 19	4.7	64.2	0.0
	12 45	15.0	82.9	68.0
	34 07	83.4	85.5	68.0
	42 32	110.9	94.2	97.6
	46 20	127.7	98.2	115.0
	52 05	147.7	96.1	134.5
	56 09	166.1	95.7	154.0
	7 00 19	189.9	92.4	179.0
	04 45	205.3	79.1	199.5
	09 05	207.4	58.7	220.0
	11 48	207.5	47.0	231.0
	17 30	193.5	24.1	257.0
2. October 6, 1919. Observed by Pettit. Spectroheliograph. The "rocket" prominence.	4h39m21s	1.7	20.3	.....
	49 50	0.2	21.9	0.0
	57 12	0.6	21.5	0.0
	6 24 34	9.9	55.8	34.1
	39 27	26.2	68.8	54.8
	45 16	31.0	70.3	59.7
	57 05	46.9	83.8	76.5
	7 07 08	61.9	87.4	96.7
	16 02	79.1	88.9	114.6
	30 26	110.1	80.3	147.5
	41 53	147.6	29.4	213.0

INTERNAL MOTIONS

The question of the character of the motions relative to the forces acting may be studied indirectly by observing the motions of knots and markings. Such data are not so reliable as that just described, but are used here as correlative evidence.

It would be of interest to know whether the streamers, loops, and knots actually indicate the direction of movement of matter in the prominence, and whether the matter is moving into or out from the chromosphere. With this idea in mind nine prominences were measured in the "blink" comparator in the manner previously described.

Generally speaking, a given knot or marking will endure only over two or three plates, occasionally more, but generally losing its identity very soon. Experience in this sort of work shows the desirability of securing plates at approximately 2-minute intervals in order to follow the kaleidoscopic changes.

The prominence of May 29, 1919, proved especially rich in such points, and in this prominence alone 333 points were measured and the velocities reduced from the observed displacements. Plates XXX and XXXI represent this prominence in five stages of the eruption.[7] Figures 7 and 8 are pantograph sketches of Plates XXX and XXXI with velocity vectors representing the observed displacements of knots and other markings in km/sec. Plate XXXII represents the eruptive prominence of July 15, 1919, at three stages of the eruption, and Figure 9 is a pantograph sketch with velocity vectors. Figure 10 is a pantograph sketch of the "sigma" prominence of September 23, 1919, in six stages. In all these prominences it will be noted that the direction of motion of the knots is along the streamer into the chromosphere. In the first two cases a spot was the principal objective of motion, but in the last case no spot was present. This was also true of the "rocket" prominence of October 6, 1919.

Velocities of knots reduced directly from displacements observed in eruptive prominences require a correction for the motion of the prominence itself in order to reduce them to values relative to the sun's limb, i.e., the velocity of the prominence should be added to the vertical component of the knot as observed.

If this were done algebraically the equations would take the form:

$$\tan \theta' = \frac{V \sin \theta + V_p}{V \cos \theta}, \tag{4}$$

or

$$V' = \sqrt{V^2 \cos^2 \theta + (V \sin \theta + V_p)^2}, \tag{5}$$

$$V' = \frac{V \sin \theta + V_p}{\sin \theta'}, \tag{6}$$

where θ and V are observed position-angles and velocities, the θ' and V' are the corresponding corrected values, and V_p the velocity of the prominence at the time. Since there would be over three hundred of the transformations for the May 29, 1919, prominence alone, a graphical method was adopted.

An accurate cross-section sheet, 16×20 inches, ruled to 0.1-inch divisions was provided with a quadrant (of 10-inch radius graduated to degrees) in one corner. Two vector arms made of the same paper read the values of V and V', and the value of V_p was laid off with dividers set for the velocity of the prominence. The values of the velocities given by the vectors as shown in the foregoing prominences are given in Table VII.

When data of this kind are studied, it will not be surprising that anomalous quantities should sometimes have to be dealt with.

From the list of measures, series of points located along a streamer were selected, and the distances from the [illegible] were measured by means of a scale bent along the streamer. The plot of these values

[7] *Astrophysical Journal*, 50, 1919.

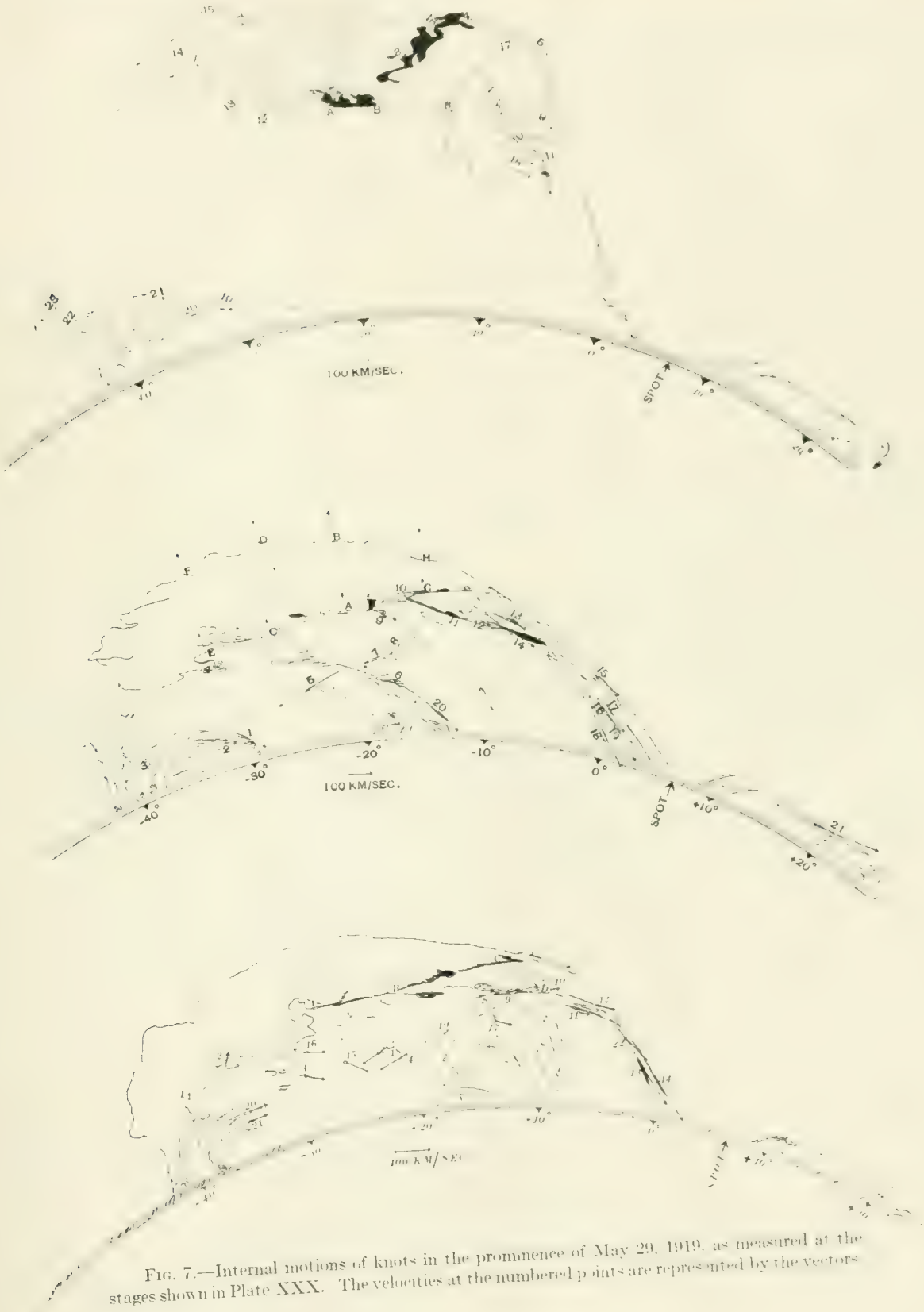


FIG. 7.—Internal motions of knots in the prominence of May 29, 1919, as measured at the stages shown in Plate XXX. The velocities at the numbered points are represented by the vectors

PLATE XXI. Rotational motions of forms in the photosphere of May 29, 1919, as measured by the Doppler effect. See Plate XXII. The velocities of the numbered points are represented by the vectors.

TABLE VII

	Point No	Meas. P.A.	Meas. V.	Corr. P.A.	Corr. V.
		Degrees	km/sec	Degrees	km/sec
a. May 29, 1919. Fig. 7, stage (*a*). Prominence at rest at this stage.	1	275.0	6.5		
	2	289.0	22.2		
	3	14.9	55.5		
	4	155.6	88.1		
	8	5.9	31.2		
	9	357.4	36.1		
	10	3.1	22.3		
	11	24.1	28.7		
	12	22.2	50.8		
	13	63.1	122.4		
	14	63.5	130.6		
	15	28.4	65.9		
	16	5.8	59.6		
	17	19.3	44.1		
	18	152.4	83.2		
	20	342.2	49.0		
	21	341.1	58.5		
	22	51.2	91.1		
	AB	170.5	11.9		
	BC	165.8	8.0		
	BD	180.6	8.3		
b. May 29, 1919. Fig. 7, stage (*b*). Prominence velocity, 5.5 km/sec.	1	22.8	53.8		
	2	0.0	29.4		
	3	340.7	6.1		
	4	3.3	19.3	19.0	20.4
	5	152.9	109.1	150.4	111.6
	6	44.9	86.2	47.3	90.5
	7	149.9	55.7	145.2	58.5
	8	137.8	22.6	129.1	26.6
	9	17.7	43.6	24.1	45.6
	10	22.7	13.1	40.9	16.0
	11	23.2	38.2	29.9	41.7
	12	22.9	34.8	30.6	37.4
	13	33.1	42.4	38.8	45.6
	14	25.9	42.5	32.0	45.2
	15	45.8	77.7	48.5	81.6
	16	54.8	91.5	56.7	96.1
	17	59.1	64.2	61.2	68.4
	18	64.2	132.9	65.0	137.9
	19	62.0	108.2	63.2	113.2
	20	45.7	84.5	48.2	88.5
	21	25.2	155.4		
	A	267.0	59.9	266.6	54.4
	B	264.5	102.8	264.3	97.4
	C	258.6	52.3	257.1	46.9
	D	258.6	84.7	257.6	79.0
	E	252.7	67.8	251.5	62.5
	F	252.6	75.6	251.5	70.4
	G	268.5	39.3	268.5	33.8
	H	268.5	99.0	268.5	93.5
c. May 29, 1919. Fig. 7, stage (*c*). Prominence velocity, 14.7 km/sec.	1	329.0	19.3	16.0	17.3
	2	295.1	23.5	326.5	11.9
	3	314.5	30.0	342.4	22.0
	4	334.6	34.0	0.2	30.9
	5	312.5	14.5		
	6	306.9	17.6	3.5	10.5
	7	358.2	35.4	21.0	38.0
	8	357.7	23.3	30.7	27.1
	9	6.3	35.4	28.0	40.0
	10	37.7	76.4	45.3	86.2
	11	89.8	106.9	90.0	121.6
	12	304.1	19.1	354.5	10.8
	13	303.5	26.7	332.7	16.6
	14	298.8	19.2	347.2	9.5
	15	269.8	8.6	90.0	6.1
	16	276.5	11.6	66.9	3.7
	17	320.2	26.3	354.2	20.4
	18	18.2	62.5	29.8	68.6
	19	24.7	25.0		
	20	338.6	10.9		

	Point No.	Meas. P.A.	Meas. V.	Corr. P.A.	Corr. V.
		Degrees	km/sec	Degrees	km/sec
c. May 29 *Continued*	21	350.4	18.4		
	22	314.6	16.3		
	23	312.5	14.5		
	AB	271.2	24.5	273.2	9.8
d. May 29, 1919. Fig. 8, stage (*d*). Prominence velocity, 27.9–60.0 km/sec.	1	301.3	68.1	2.9	36.0
	2	295.6	23.9	75.2	40.1
	3	295.5	62.5	8.4	27.3
	4	295.3	39.8	49.3	26.2
	18	343.1	18.0		
	19	312.7	21.4	39.6	19.0
	20	312.4	51.1	344.5	36.0
	22	324.0	54.9	354.7	44.8
	A	306.1	26.3	24.0	16.8
	B	277.7	39.4	295.5	12.5
	C	340.2	55.3	10.2	53.0
e. May 29, 1919. Fig. 8, stage (*e*). Prominence velocity, 60 km/sec.	2	267.4	44.9	102.6	15.4
	4	120.5	35.4	54.5	31.0
	5	346.4	43.5	49.7	65.8
a. July 15, 1919. Fig. 9, stage (*a*). Prominence velocity, 37.0 km/sec.	1	261.1	61.6	247.0	25.4
	2	295.4	38.7	8.5	16.6
	3	352.5	56.7	28.2	64.0
	4	5.4	53.3	38.6	68.0
	5	257.2	75.9	81.5	112.5
	6	39.2	91.9	53.0	119.0
	7	90.0	62.4	90.0	99.4
b. July 15, 1919. Fig. 9, stage (*b*). Prominence velocity, 163.9 km/sec. No points were identifiable in stage (*c*).	AB	252.8	139.7		
	2	271.5	63.5	89.2	100.0
	3	272.1	64.2	88.9	100.3
	4	322.2	50.0	73	138
	5	340.5	52.5	71	152.5
	6	47.6	148.8	69.5	291
	1	74.2	117.9	83.6	281
a. September 23, 1919. Fig. 10, stage (*a*). The "sigma" prominence. Exposure at $4^h55^m40^s$ G.M.T.	1	293	53.7		
	2	299	59.8		
	3	293	44.6		
	4	2	23.5		
	5	285	49.2		
	6	6	25.9		
	11	279	70.1		
b. September 23, 1919. Fig. 10, stage (*b*). Exposure at $6^h00^m52^s$.	1	193	64.4		
	2	263	80.2		
	3	279	60.3		
	4	353	28.0		
	5	32	61.8		
	6	359	33.4		
	7	218	95.3		
c. September 23, 1919. Fig. 10, stage (*c*). Exposure at $6^h12^m45^s$ G.M.T.	4	254	39.6		
	6	4	46.5		
	9	38	38.1		
d. September 23, 1919. Fig. 10, stage (*d*). Exposure at $6^h34^m07^s$ G.M.T.	6	314	67.1		
	1	314	56.0		
e. September 23, 1919. Fig. 10, stage (*e*). Exposure at $6^h46^m20^s$ G.M.T.	6	296	64.0		
	1	189	84.3		
	2	268	73.2		
	3	234	84.8		
	4	279	63.3		
f. September 23, 1919. Fig. 10, stage (*f*). Exposure at $7^h09^m05^s$ G.M.T.	6	203	92.9		

of the velocity, as ordinates, against the distance of the knot from the center of attraction, as abscissas, for the prominence of May 29, 1919, is given in Figure 11. The mean curve for each streamer was plotted, but only the mean of all the curves is shown here as a full line.

A study of this curve shows that the velocities increase, from about 25 km sec. at 500,000 km above the chromosphere to about 200 km sec. at the chromosphere, according to an exponential law which would give nearly constant velocities for points high up. One must, of course, take this curve to represent only the approximate general relation of velocities to distance, and not an exact statement of the conditions obtain-

FIG. 9.—Internal motions of knots in the prominence of July 15, 1919, as measured at the stages shown in Plate XXXII, *a* and *b*. The velocities at the measured points are represented by the vectors.

ing at any point. Doubtless the velocity of a given knot is a function of its mass and other unknown physical quantities, as well as of its distance.

That gravity may or may not play a part in the descent of matter in the streamer may be determined by comparing the observed velocities with the values computed by the gravitational formula.

By way of anticipation one might suppose that the velocities observed would exceed those computed, since it is quite certain that the center of attraction, the spot, is exerting a force on the matter in the streamer which is the principal cause of the whole phenomenon. Curiously enough, however, this is not the case, as will be seen from Table VIII taken from plates where velocities near the chromosphere were measured

The value at the chromosphere obtained from the mean curve (Fig. 11) is added by way of comparison. In Table VIII, s_1 represents the apparent origin of the streamer at the point where it appears to leave the main body of the prominence measured from the center of the sun, and s_0 is the observed distance of the

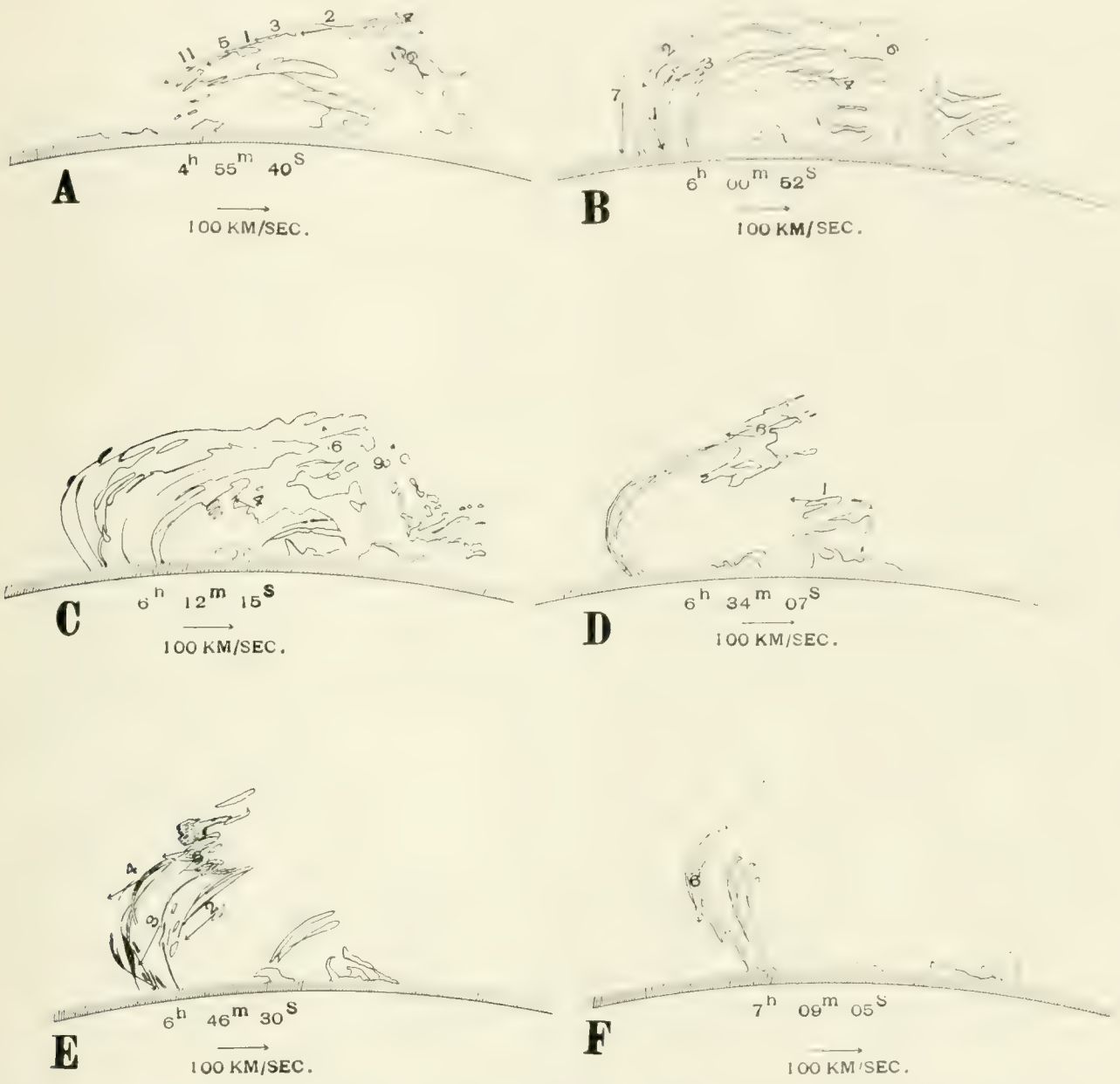


FIG. 10.—Lateral and internal motions of knots in the prominence of September 23, 1919, as measured at the corresponding stages shown in Plate XXVIII. The velocities at the numbered points are represented by the vectors.

knot from the center of the sun at the point where the velocity observed, $V_{obs.}$ was measured. $V_{comp.}$ is the velocity computed from the general gravitational formula

$$V_{comp.} = \sqrt{2gR^2 \frac{s_1 - s_0}{s_1 s_0} + V_1^2} \qquad (7)$$

where V_i is the initial velocity. When V_i is put equal to zero, the formula becomes equation (1) on page 208. In equation (7), V_i was taken equal to zero except in the case of the mean curve, where it was taken to be 25 km/sec. $V_{obs.}$ is the vertical component of the measured velocity, since gravity acts in that direction

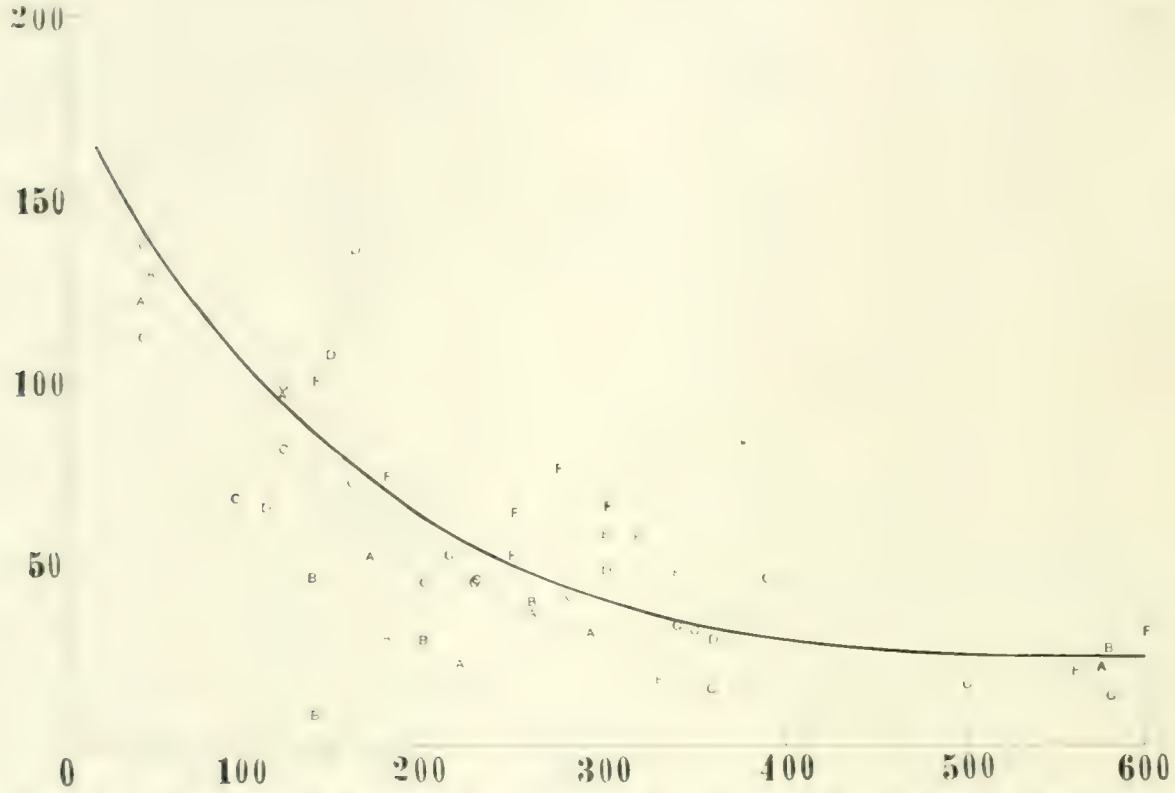


FIG. 11.—Plot of the motions of knots along the streamers in the prominence of May 29, 1919. The ordinates are velocities in km/sec., and the abscissas are distance from the center of attraction in thousand kilometers.

TABLE VIII

[illegible]	Knot No.	[illegible]	[illegible]	$V_{comp.}$	$V_{obs.}$	$\frac{V_{obs.}}{V_{comp.}}$
		km	km	km/sec	km/sec	
70.....	14	735,600	815,600	187	97	0.52
76.....	18	715,600	855,600	244	102	.41
78.....	12	755,600	865,600	210	86	.41
80.....	26	775,600	855,600	177	53	.30
81.....	18	775,600	855,600	177	63	.36
88.....	15	815,600	1,015,600	251	89	.35
89.....	19	815,600	1,035,600	261	94	.36
90.....	16	775,600	1,070,600	305	110	.36
91.....	2	755,600	1,075,600	321	65	.20
*		695,600	1,195,600	421	200	.5

* [illegible]

and it is obtained by applying the coefficient $\cos(\theta-\phi-180°)$ to the measured velocity, where θ is the position-angle of the knot and ϕ is the position-angle of the vector of motion, the sign of the coefficient above being taken as positive.

Judging from the fact that the observed velocities are only from two-tenths to five-tenths of the values that ought to have risen the gravitational component alone, and neglecting the attraction of the spot (which is the principal center of attraction in this case) altogether, one is led to question whether gravity has

anything to do with the motions of these knots. This view is further strengthened by data taken from the other eight prominences mentioned on page 223. These data are collected for comparison in Table IX.

TABLE IX

Prominence	Plate No.	Knot No.	s_0	s_1	$V_{comp.}$	$V_{obs.}$	$\frac{V_{obs.}}{V_{comp.}}$
			km	km	km/sec	km/sec	
July 15, 1919	26	2	765,600	945,600	255	79	0.31
July 15, 1919	29	1	735,600	1,015,600	313	102	0.32
September 23, 1919	Graph		695,600	790,600	212	54	0.35
September 24, 1919	06	1	705,600	735,600	127	11	0.09
October 6, 1919	Graph		695,600	782,600	204	95	0.47
March 27, 1920	59	4	695,600	735,600	147	25	0.17

It may be said, then, that in general these knots have velocities which are in the neighborhood of one-third or one-fourth of that which gravity alone ought to give to them.

MOTIONS IN THE PROMINENCES OF THE SPOT OR "SPLASH" TYPE

Particular interest is attached to prominences connected with the spots, in that they, without doubt, serve as indicators of the extended field of activity, which may have produced the spot itself.

Slocum[8] has cited two cases of prominences near spots, in which accelerated motion of the matter into the spot was observed by him. Evershed,[9] however, in writing about the Kodaikanal observations says, ". . . . but we have never seen any evidence of the attraction of sun-spots for prominences," and again (*op. cit.*, p. 106), "No case has been found in which prominences were falling into sun-spots, but the reverse has several times been observed." His general conclusion (*ibid.*, p. 91) is that

> The investigation has confirmed our previous belief that gas is always rising in the center of this type of prominence, and that this uprushing gas has a tendency to fall back upon the chromosphere at some distance from the sun-spot, sometimes building up banks or columns there (see Plate IX, Figs. 3 and 4), sometimes apparently continuing to rise and fall like fountains in the form of arches (Plate IX, Figs. 5 to 8), so that a fully developed spot-prominence covers a large space.

The plates referred to are not reproduced here.

A glance at Figures 7, 8, and 9 will convince one that the matter in the prominences of May 29 and July 15, 1919, was moving into the spot in each case connected with the prominence—and that in spite of the fact that the prominences were rushing upward, away from these spots, with high velocities, and that the spot in each case was of the round "normal" type. Plate XXXIII shows a direct photograph and a calcium spectroheliogram of the spots connected with the prominence of May 29, 1919.

In order to secure additional evidence, three prominences of the splash type and one of the fountain type were observed at short intervals and the motions measured in detail in the "blink" comparator.

The first of these, the splash prominence of August 17, 1917 (observed by Mrs. Pettit and myself), was connected with the great spot of that month. This spot was the largest and most active of the present cycle. Plate XXXIV shows a calcium spectroheliogram of both spot and prominence. Figure 12 is a pantograph sketch of this prominence. A streamer from the suspended wing is moving into the spot at the rate of 8 km/sec., and an isolated knot is descending with a velocity of 1 km/sec. The low, detached prominence under the wing is being projected into a point of attraction 250,000 km away at the rate of 7.4 km/sec.

The prominence of March 27, 1920, was connected with the great spot of that month. Plate XXXV shows this prominence and the associated spot. In this case 49 points were measured on a series of 21 exposures.

[8] *Astrophysical Journal*, **36**, 265, 1912.

[9] *Mem. Kod. Obs.*, **1**, Part II, 93.

Velocities into the spot seemed to average 30 km/sec. Two cases of repulsion were observed—one a streamer projected from the suspended cloud, and one an eruption from the same cloud. The first followed a flat trajectory and re-entered the chromosphere 150,000 km away. The eruption, on the other hand, rose nearly vertically with a uniform velocity of 25 km/sec. and faded away. This was followed with 6 exposures over a period of 15 minutes. The measures were made in the comparator.

The prominence of March 29, 1920, was also associated with this spot group. In this case 15 measures on 5 exposures were made. Two low splashes endured throughout the series. Three exposures were made on the high, separated splash. This prominence is shown in Plate XXXV. The first two splashes were moving into the spot with a slowly increasing velocity of 40 km/sec. and the high splash with a velocity of 10 km/sec.

The prominence of September 22, 1919, was an excellent case of the fountain type. On 15 exposures made at intervals of 5 minutes, 41 points were measured in the comparator. These measures indicate an average velocity of 35 km/sec. into the spot. One streamer was caught in the process of forming a closed loop of the fountain. This is the central streamer of the figure (Plate XXXVI) slightly inclined to the left. For half an hour, up to the seventh exposure, it had been standing motionless. On the eighth and succeeding exposures it is seen to descend, the whole column seeming to break away and follow it in its arched path.

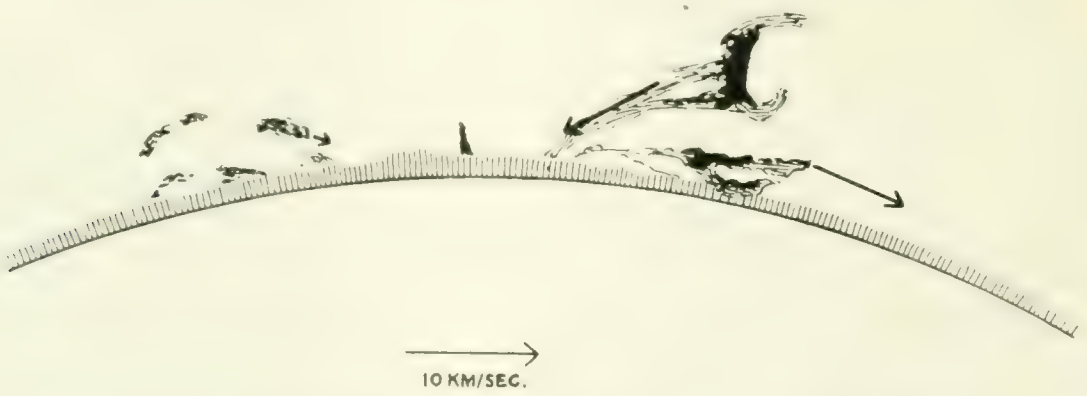


Fig. 12.—Lateral and internal motions of knots in the splash prominence of August 17, 1917, which was situated over the great spot of that month.

The velocity of the ascending end was 30 km/sec. The descending end had approximately the same velocity until about halfway down when the velocity increased to 80 km/sec. On the fourteenth exposure it touched the chromosphere and on the next exposure it had disappeared. Only 2 cases of repulsion were observed in this prominence out of the 41 measured points.

Slocum[10] gives velocities of "16, 20, and 60 km per second" for three knots in his prominence of October 8, 1910, moving into a spot. These plates were remeasured in the comparator as previously described and the values 5.2, 8.0, and 44.3 km/sec. obtained. Two other knots at the left (*op. cit.*, Plate XI, 4^h34^m9), not mentioned by Slocum, were measured. Their distances from the spot as indicated by Slocum's arrow are 125,000 and 100,000 km, and their velocities 19.7 and 37.8 km/sec., respectively, toward the spot.

In his prominence of October 22, 1910 (*loc. cit.*), Slocum gives velocities of 80 and 110 km/sec. for two intervals between three exposures. All three knots in the streamer were measured in the comparator and I get for the first pair of exposures 18.4, 31.1, and 85.8 km/sec. in order of their increasing distances from the spot. For the small detached mass at the right I get 34.8 km/sec. Slocum gives 10,000 km/sec., which is obviously an error of printing.

Plotting these velocities against the distance of the knot from the spot, a nearly linear increase of velocity with the decrease of distance is obtained. The vertical component of the maximum velocity observed here was 52 km/sec. against 168 km/sec. computed by the gravitational formula, assuming the matter to have

[10] *Astrophys. J.*, 36, 265, 1912.

started from the point where the streamer leaves the prominence. Here, again, it seems that gravity can have little to do with the motion of the matter into the spot.

The prominence of May 9, 1911, was a splash over a small active spot on the southwest limb. Two exposures were taken by Slocum under good observing conditions and with an interval of 2 minutes (Plate XXXVII). I have measured the 4 small knots in the splash directly over the spot and 2 knots in the streamer at the left. The velocities obtained are given in Table X, all of which are directly toward the spot.

TABLE X

Point No.	Velocity	Point No.	Velocity
	km/sec		km/sec
1	38.4	4	54.9
2	69.6	5	21.3
3	31.1	6	21.3

Occasionally a brilliant spike will be projected from the vicinity of a spot, and, rising 20,000 or 30,000 kilometers, will fall again in the same region in a more or less circular arc. These are of the class of metallic prominences. One of these was observed on July 3, 1920, over an active spot on the west limb. It rose with a velocity of 30 km/sec., and, breaking into a spray at the highest point reached, precipitated itself on to the spot 25,000 km below. A broken stump remained as a brilliant spike, gradually fading during the next two hours.

In all the prominences here described and in any others which I have observed, no tendency for the prominence gases to pile up after falling back on the chromosphere was ever noted. On the contrary, they entirely disappear, like water poured into a pond. The prominences shown on Plates XXVIII–XXXII illustrate this. I cannot believe that "this uprushing gas has a tendency to fall back on the chromosphere at some distance from the spot, sometimes building up banks or columns there." In fact, I have shown a number of cases here where the matter was moving from the "banks" into the spot. I am convinced that this is the normal state of affairs, and that the "banks or columns" are of a more or less accidental nature—probably having risen through the coarser structure of the solar surface in the neighborhood of the spot—and are subject to the attractive forces emanating from the spot.

CENTERS OF ATTRACTION

That there are centers of attraction on the sun, where no spot or other marking appears, is to be inferred from the common circumstance of prominences from which streamers extend nearly parallel to the limb, finally turning downward and terminating in the chromosphere. The prominences of September 23, 1919, and October 6, 1919, already cited, were phenomena of this sort. Two such centers of attraction appeared under the prominence of May 29, 1919, at latitudes $-10°$ and $-25°$ (see pantograph sketch, Figures 7 and 8). Indeed, the streamers from the prominence descended to the former point, in preference to the spot, when the prominence had attained a height of 760,000 km.

Further evidence that the attraction is felt far out beyond the regions of the prominences is indicated by the effect of such a point which appeared on the western limb during the eclipse of June 8, 1918, at latitude 15° north, nearly midway between the "heliosaurus" and the neighboring prominence on the north, two prominences which attracted attention on account of their form. At the point where the streamers from the two prominences seem to converge into the chromosphere, the streamers of the corona radiate away in a striking fanlike form, strongly suggesting the "lines of force" about the pole of a magnet. On the photographs taken at Matheson, Colorado, these streamers can be traced at least a solar diameter from the center of attraction. The effect is nicely seen in the painting by Howard Russell Butler, from his visual observations, supplemented by a study of photographs of the eclipse.

That many of the cases of leaning prominences are due to such centers of attraction rather than to any atmospheric current, of the nature of a wind, in the corona may be inferred from the circumstances just

related. No stream effect of the kind one would expect, if winds in the corona actually produced these forms, has been found to exist. The case just cited, at the eclipse, certainly could not be so classified.

STUBBORN KNOTS AND EDDIES

A curious phenomenon was occasionally encountered in the measurement of the internal motions of prominences. Generally all the bright knots in a given region of a prominence were found to move with approximately the same speed and general direction. Occasionally one of these knots would remain stationary over several exposures, finally to be dragged along, rather reluctantly, with the rest of the matter which had been rushing past it at 20 or 30 km/sec.

In at least two cases these stubborn knots appear to have been the cause of an eddy in the prominence. In the prominence of May 29, 1919, these were first encountered near the points A and B in Figure 7*c*. Other points arranged themselves on either side of these, moving with low, slowly increasing velocities, in the reverse direction of the general stream toward the spot. A spiral arrangement then began to manifest itself, the free end of the prominence rotating like a corkscrew.

The linear velocities of 5 points on Plate XXXI were measured in the last exposures, and from these values, and the radius of the spiral, the period of rotation is given in Table XI.

TABLE XI

G.M.T.	*R*	*V*	*P*
	km	km/sec.	
7h19m	90,000	40	3h56m
7 57	110,000	32	6 00
8 23	140,000	37	6 35

The prominence of September 11, 1919, had the appearance of the quiescent type, in the forenoon. Toward afternoon a streamer extending out of one side indicated a strong attraction in that direction. Between 2^h50^m and 3^h20^m the whole prominence was torn apart, and it drifted off in the direction of the streamer with a mean velocity of 35 km/sec. Mean velocities of 50–60 km/sec. were maintained by knots at various times until the last exposure at 5^h45^m.

A stubborn knot appeared at 3^h45^m, and at 4^h6^m it began a slow retrograde motion. An elliptical eddy formed, and in the next five minutes the matter on one side was moving in one direction with a velocity of 55 km/sec., and on the other side with an equal velocity in the other direction, while the matter at the two ends of the ellipse appeared to be stationary. The diameter of the eddy was 70,000 km, whence the period of rotation was 1^h7^m.

A peculiar case was observed in the "rocket" prominence of October 6, 1919. This was the prominence from which a piece was torn away, and, following a circular trajectory, re-entered the chromosphere. A notch appears just under the point of this comet-like portion in the sixth exposure shown on Plate XXIX. It can be traced a little farther back into the tail each time in the succeeding exposures until the tenth one is reached. As a matter of fact, this notch is stationary and the prominence is moving over it in much the same manner that a rope would appear when dragged over a log. Here, then, we have an invisible stubborn knot, probably made of matter which does not radiate the H line of calcium.

STATISTICAL DATA ON ERUPTIVE PROMINENCES

1. *Velocities generated during an eruption.*—The twenty-four cases of eruptive prominences already given cover all the published data which I have been able to find, in which more than three observations were made during the rise of the prominence. It is obvious that where only two observations have been made the actual values of the velocities and heights are rather problematic, especially in the visual results. This applies more particularly to the more rapid motions.

The mean intervallic velocity for the 24 cases is 153 km/sec. and a maximum velocity of 400 km/sec. was attained in [illegible]

All cases of prominences reaching a height greater than 150,000 km were collected. Of the 25 cases found, not including any of the foregoing, the average velocity is 298 km/sec. This high average is due to several individual, high velocities. Buss observed one on March 3, 1907, which reached a height of 750,000 km with a velocity of 600 km/sec. I have been unable to learn the details of the observation. Trouvelot observed one on July 11, 1892, which reached a height of 427,000 km with a velocity of 715 km/sec. Lockyer observed velocities of 300–400 km/sec. Secchi states that "Respighi declares he has observed 'initial' velocities of 600, 700 and even 800 km/sec.," but that "these figures are in need of confirmation." If this means that the "initial" velocities were reduced from the observed velocities with the gravitational theory, then the values are erroneous in the light of what we have seen to be the character of the motion of eruptive prominences.

Fényi observed an eruption on June 17, 1891, in which a radial velocity of 800 km/sec. was measured and a velocity of ascent of 485 km/sec. observed. The circumstances of the observation, however, were not the best. The whole ascent only lasted about 210 seconds, during which he observed 7 transits of both apex and base, determined the line-of-sight velocity with the micrometer, and observed the character of the spectrum. The duration was computed from the times of transit, allowing suitable time for resetting the telescope and making the record. An error in this estimate, of course, would affect the result abnormally on account of the short duration.

Proctor is often quoted for a velocity of 800 km/sec., but this was an initial velocity computed from Young's observation at Sherman, Wyoming, on September 7, 1871, when a velocity of 217 km/sec. was observed. The computation was based on the gravitational theory and a hypothetical atmospheric resistance.

All these observations were made visually, with rather short intervals and two observations of the time, and consequently they are subject to a large percentage of error.

Line-of-sight velocities as high as 1000 km/sec. have been reported several times. The interpretation of these results is somewhat doubtful as yet. Generally no two lines of the same element will give even approximately equal velocities, and other elements show no shifts at all. Young's observation of August 3, 1872, illustrates this point.

We may conclude, then, that velocities greater than 400 km/sec. occur only rarely, and the results cited above must be accepted with caution until confirmed by photography.

2. *Positions of the breaks in the curves.*—There seems to be no general connection among the breaks in the curves. Thus in the prominence of May 29, 1919, there were 4 breaks in 760,000 km, while in that of July 15, 1919, there is only 1 break in 720,000 km. This circumstance would preclude the theory of a stratified atmosphere, as an explanation of the sudden increases in velocity, unless one may suppose that the stratification varies in an erratic manner.

3. *The distribution in latitude.*—This shows a strong maximum in the sun-spot zones, although some have been observed in high latitudes. Deslandres' prominence of May 31, 1894, appeared in latitude 80°. Those observed in the past ten years appeared almost entirely in the hemisphere 0°–190° of longitude, while those observed prior to that interval regress into the other hemisphere.

4. *Relation of the velocity to height.*—Generally speaking, the higher prominences have the higher velocities, as one might expect to result from the principle of motion found to obtain. There are, on the other hand, numerous instances of high velocities at low altitudes. Buss observed a velocity of 280 km/sec. in a prominence which reached a height of only 30,000 km. At this point the normal velocity is only 5 or 10 km/sec.

5. *Relation between spots and eruptive prominences.*—That there is, in general, no apparent connection between spots and prominences has been shown by Lee.[11] This applies to eruptive prominences in particular. While the eruptive prominences of May 29 and July 15, 1919, were associated with sun-spots, yet in this respect they were quite in a class by themselves. No other eruption observed with a spectroheliograph shows any connection between a spot and an eruptive prominence, and generally no marking appears on the disk-plate in the region of the eruption.

[11] *Astrophysical Journal*, **45**, 206, 1917.

While the evidence of the visual observers is not of such a certain nature, and occasionally no mention is made of the condition of the disk in the region of the eruption, the same general rule applies here, that the connection between sun-spots and eruptive prominences is of a purely accidental nature. Indeed, one would suppose that the presence of the spot would hinder rather than excite the eruption, judging by the rapid descent of the matter into the spot in the two cases cited.

6. *No change in form or in any other respect* can certainly be distinguished in the prominence at the time when the sudden change in velocity (the "impulse") occurs. This, of course, is based on a study of the spectroheliographic plates and the prints available to me, and is not complete. The visual observations contribute nothing to studies of this kind. Altogether no safe conclusion can be drawn on this point from the material covered in this investigation.

SUMMARY OF THE PRINCIPAL OBSERVATIONAL EVIDENCE

1. Prominences of the splash type are always connected with sun-spots, and consist of one or two wings on either side of the spot with projecting spikes radiating away from it, many of them broken and describing curves similar to the "lines of force" about a magnet. Normally the matter about the spot is moving into it with accelerated velocities averaging about 35 km sec., sometimes reaching 100 km sec. Occasionally a streamer may be projected from one of the wings away from the spot, or a spike rise from the region of the spot, with similar velocities. This is not the normal condition, however. The distribution of these objects observed in the last twelve years shows a sharp maximum in longitude 145°.

2. Tornado prominences are found to be twisted in one direction only, such that the direction of rotation is interpreted to be in the clockwise direction in both hemispheres.

3. Eruptive prominences have been shown to move with uniform velocity, suddenly accelerated at intervals as if by an impulse. This conclusion is substantiated by both visual and photographic observations in every case where sufficient data are obtainable to determine the character of the motion.

4. There is some evidence of secondary eruptions and possible decrease of velocity at the end of an eruption, but the latter is based on only a few visual observations.

5. Fading at the end of the eruption is very rapid, sometimes obliterating the whole prominence in a few minutes, and sometimes only partially.

6. The maximum velocity observed in the best-determined cases reaches 400 km/sec. Velocities greater than this are to be accepted with less confidence.

7. Streamers and knots in prominences show velocities toward the sun's surface of about one-third that which gravity alone would give to them.

8. There is no evidence of the piling up of matter which is torn from a prominence, or ejected from the region of a spot, and which returns to the chromosphere.

9. Stubborn knots are found which sometimes appear to produce eddies in portions of a prominence where there is a streaming of matter.

10. There seems to be no connection between eruptive prominences and spots, other than of an accidental nature.

11. There is no apparent relation between the breaks in the curves and the heights which they indicate.

THE PROBABLE NATURE OF ERUPTIVE PROMINENCES

That we have to deal with real motions of bodies of gaseous matter and not with a "transference of luminescence," as Brester imagined, is difficult to prove, as no crucial test has yet been devised to settle the question, but the motions of the knots and streamers are such as to give a strong impression of the actual transference of matter. The delicate detail of a prominence, which, in its more general structure, often undergoes only a slow change while the whole body is moving with a velocity of 200 km/sec., can hardly be compared to the [illegible] as an example of the "transference of luminescence."

If we accept this view of the matter the question now arises as to the origin of the eruptive forces which produce these high velocities. Young's idea, which was accepted as the best available by many of

his contemporaries, may be briefly summarized as follows. The photosphere consists of the condensed cloud surface, of which the granules are the upper ends of columns of condensed vapors, between which rise the heated currents from within, and in their passage through these "quasi-pipes" they may encounter contracted passages which may result in explosions giving rise to motions "which must have exceeded 200 miles per second" in the prominence of September 7, 1871.

Secchi was inclined to attribute a great part of the velocity to an extreme difference of density between the prominences and the atmosphere in which they rise.

Both of these views of the mechanics of an eruption of a prominence are untenable for cases of quiescent prominences which later become eruptive. The prominence of May 29, 1919, was a case of this kind.[12] Young's view would necessarily admit a complicated spectrum, which is not generally the case, for the spectrum is often as simple as that of the quiescent prominences. Secchi's view would reverse what seem to be the relative densities of the prominences and the corona. Secchi was under the impression that the hydrogen spectrum is present in the inner corona, which is now believed not to be the case.

Arrhenius and others have attempted to use radiation pressure to explain comets' tails, prominences, and the corona. Fitzgerald first suggested that the light-pressure on gases is equal to the pressure exerted on a black body of equivalent cross-section multiplied by the coefficient of absorption of the gas. Lebedew tested this theory experimentally and showed that the relationship stated by Fitzgerald is correct within 30 per cent of the predicted value, which was the limit of accuracy attainable by the method he used. His conclusion[13] was, however: "These experiments refer to masses of gas under atmospheric pressure, and the numerical values found cannot be directly applied to the excessively rare gases of comets' tails." The coefficients which he found were of the order of less than 0.01.

That there is a certain dimension for which the light-pressure is a maximum per unit area on a small spherical body was first pointed out by Schwarzschild. He showed that, from considerations based on the electromagnetic theory of light, the pressure is a maximum per unit area, when the circumference of the sphere is about equal to the wave-length of the radiation incident on it. The pressure is then over twice the value given by the energy formula. As the diameter diminishes, the pressure falls off in an exponential manner on account of diffraction effects, and is rapidly reduced to zero.

The appearance of Halley's comet brought forth a number of papers on the subject. Nicholson[14] gives a shorter method of reducing the equations, and Proudman,[15] a still shorter method. Debye[16] discusses light-pressure on small spherical particles and molecules of various hypothetical constructions. In all these, the equations lead to the determination of the quantity $P/\pi a^2 E$, which is the ratio of the pressure computed by the electromagnetic theory to the pressure computed by the simple assumption that the energy received per unit volume of the incident beam is all converted into a repulsive force. Curves giving this ratio in ordinate against the argument $2\pi a/\lambda$ (the circumference in terms of the wave-length) are given by the authorities quoted above.

On the assumption that the molecule is a small spherical absorbing body we may compute the radiation pressure from the formulae mentioned above. We will follow Nicholson. He gives (*loc. cit.*):

$$\frac{P}{\pi a^2 E} = S_2 + \eta + \zeta \tag{8}$$

$$S_2 = \frac{2}{k^2 a^2} \sum_1^\infty \frac{2n+1}{n(n+1)} \frac{1}{1+T_n^2} \tag{9}$$

$$\eta = \frac{2}{k^2 a^2} \sum_1^\infty \frac{n(n+2)}{(n+1)} \frac{1}{R_n R_{n+1}} \tag{10}$$

$$\zeta = \frac{2}{k^2 a^2} \sum_1^\infty \frac{n(n+2)}{n+1} \left[\frac{(n+1)^2}{k^2 a^2} - 1 \right] \sigma_n \tag{11}$$

[12] *Astrophysical Journal*, **50**, 207, 1919.

[13] *Ibid.*, **31**, 393, 1910.

[14] *Monthly Notices*, **70**, 544, 1910.

[15] *Ibid.*, **73**, 535, 1913.

[16] *Annalen der Physik*, **30**, 57, 1909.

The diameters of molecules of various gases have been determined by a number of methods in recent years. The values obtained are of the order $2\cdot10^{-8}$ cm. For hydrogen the mean value is about $1.12\cdot10^{-8}$ cm. This gives, then, $a=0.56\cdot10^{-8}$ cm, and taking λ at $5.5\cdot10^{-5}$ cm for the effective wave-length of radiation we have

$$Z=\frac{2\pi a}{\lambda}=0.001274, \qquad R_{-1}=1, \qquad R_1=1, \qquad R_3=6.16\cdot10^{-9}, \qquad R_2=3.4\cdot10^{12}.$$

From these values it is readily seen that only the value $\nu=1$ need be taken in the summation. Then, from these values:

$$\sigma_1=7.7\cdot10^{-9}$$
$$S_2=79\cdot10^{-13}$$
$$\eta=8.8\cdot10^{-13}$$
$$\xi=35\cdot10^{-13}$$
$$\frac{P}{\pi a^2E}=12.3\cdot10^{-12} \tag{12}$$

A simple check formula $\frac{P}{\pi a^2E}=\frac{14Z^4}{3}$ may be applied here, and the value of Z being so near the origin the check ought to hold with considerable accuracy. From this formula we get:

$$\frac{P}{\pi a^2E}=12.3\cdot10^{-12}.$$

Let us now consider the pressure on a molecule of hydrogen near the chromosphere. For all practical purposes we may consider the radiating surface to be a plane of infinite extent.

In Figure 13 let m represent the molecule from which the perpendicular h is dropped to the radiating surface. Let the energy of radiation per unit area from the small elementary area $r\,dr\,d\theta$, falling on m, be E. The pressure P then varies directly with E, inversely with the square of the distance $=h^2+r^2$, and directly with the cross-section of the beam $r\,dr\,d\theta\,\frac{h}{\sqrt{h^2+r^2}}$. The component parallel to h is the energy so obtained, multiplied by $\cos\phi=\frac{h}{\sqrt{h^2+r^2}}$. The sum of the differential components is

$$\int_{r=0}^{r=\infty}\int_{\theta=0}^{\theta=2\pi}E\frac{h^2\,r\,dr\,d\theta}{(h^2+r^2)^2} \tag{13}$$

Integrating this, we get for the energy delivered to m, effective outward along a solar radius,

$$E'=\pi E, \tag{14}$$

and the consequent pressure for a perfectly absorbing molecule is

$$P=12.3\cdot10^{-12}\pi^2a^2E\,. \tag{15}$$

Taking the solar constant at 2 cal./min. $=1.4\cdot10^6$ ergs/sec. for the earth's distance, its value at the sun's surface will be forty-six thousand times as great, and the energy per cu. cm effective as pressure is

$$P=12.3\cdot10^{-12}\pi^2a^2E\,\frac{1}{V}=79.2\cdot10^{-28}\text{ dynes},$$

where V is the velocity of light $=3\cdot10^{10}$ cm/sec.

Now the mass of a hydrogen molecule is given by Millikan as $1.66 \cdot 10^{-24}$ gm. Taking $G = 27.6$ g we get for the ratio of the attraction of gravity Gm, to the light-pressure P, at the sun's surface, $Gm \div P = 5.7 \cdot 10^5$, i.e., gravitational attraction on a hydrogen molecule exceeds light-pressure some half-billion times, assuming the molecule to be a perfectly rigid absorbing sphere.

We cannot, of course, admit the rigid molecule as a final argument in the light of what is known to be the probable constitution of it. That "resonant pressure," due to the electrons circulating in orbits having periods approximating that of the incident radiation, probably exists, cannot be doubted. Page[17] computed the value of such a resonant pressure on molecules of sodium vapor. For resonant frequency at 9000 A the value of the pressure is a maximum, and exceeds gravitation "thirty times or more." While the derivation of this result is based on the doubtful assumption that the resonant effect is applicable for the integrated spectrum, we may accept the result and show that it does not apply to the prominences near to the chromosphere.

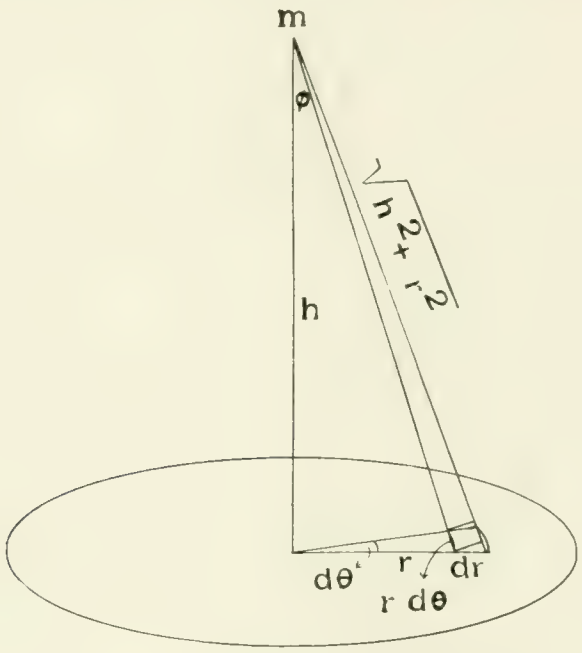


Fig. 13

In his equation for the energy received, $1/c$, he presumes radiation from a full hemisphere of the sun. For a prominence at the chromosphere, the area of the exposed radiating surface is very small and the rays are nearly all inclined at an angle, while the law of gravitation remains unchanged.

Possibly the more reasonable assumption is that the energy producing the pressure must be some part of that absorbed by the gas. Poynting[18] discusses this and arrives at the conclusion that "no gas can be repelled."

Eddington,[19] in discussing the envelopes of comet Morehouse, concluded that the velocities of the ejected particles were hundreds of times greater than those produced by gravity. Light-pressure could not account for it.

That radiation pressure does not furnish the motive power for eruptive prominences is apparent from several considerations.

1. If the radiation pressure on a molecule exceeded gravity at the sun's surface the chromosphere could not exist, neither would the quiescent prominences.

[17] *Astrophysical Journal*, **51**, 65, 1920. [18] *The Pressure of Light*, p. 92. [19] *Monthly Notices*, **60**, 442, 1910.

2. The velocities of the eruptive prominences would all be nearly the same at the same height, or at least there should be a tendency in that direction. This has been shown not to be the case.

3. Radiation pressure acts radially. Some eruptions have taken place at considerable angles to the radius. In the case of the prominence of September 8, 1919, this angle was nearly 57° and the prominence traversed this path in a nearly straight line a distance of 480,000 km.

4. If radiation pressure produced the observed motions, they would be continuously accelerated rather than uniform.

Whatever the nature of the expelling force, several properties are apparent from the observational evidence presented here.

1. The force is very probably of the same nature for all eruptive prominences, since the law of motion appears to be a general one.

2. The force acts at a distance. The quiescent prominences which become eruptive are almost detached masses connected to the sun by streamers. These are well represented in the prominence of May 29, 1919. In these streamers the matter is moving into the sun, hence the force of the eruption cannot be traveling outward along them unless it be of an electrical nature.

3. Further evidence that the force acts at a distance and also over short periods of time is obtained from the sudden increases in velocity of ascent after the prominence is entirely free from the sun.

4. It must follow the law of motion shown here to be a generalization.

5. It generally produces no visible disturbance on the photosphere.

6. It must be capable of acting between individual molecules of a gas and the sun.

7. It must produce the high velocities observed.

8. It must act at times at a considerable angle to the vertical.

9. The value of the eruptive force probably varies over a considerable range.

The character of the motion here presents peculiar difficulties, if we are to accept the precepts of Newtonian mechanics. Uniform motion in a straight line subject to sudden increases is not to be expected in a gravitational field. We must account for uniform motion observed over a space greater than a solar radius, enduring for several hours at least, and we have no reason to believe that these are limits in any sense.

Before pursuing the matter farther we are in need of two pieces of evidence quite lacking, viz., the densities of the prominences and of the coronal atmosphere. From appearances one would judge that the densities are very low, and, if anything, that the coronal density is the less. If we assume a density of 1 atmosphere in the chromosphere, the density in the region of the ordinary prominences is less than the best vacuum we can produce, on account of the value of superficial gravitation there.

Some facts bearing on the coronal density and its relation to the densities of the prominences may be stated here. The high velocities of the eruptive prominences would make a coronal density much short of a good vacuum seem impossible. That the prominences could preserve any kind of form while moving at the rate of 100 km/sec. through an atmosphere of density comparable with its own is quite inconceivable.

One point of observation must not escape attention, however. In many cases the matter of the prominence is broken up, apparently, and scattered all along the path traversed, as was the case of Young's prominence of September 7, 1871, and also of the prominence of September 8, 1919. There is some tendency to expand in the direction of motion in nearly all cases, but there are some exceptions. The prominence of July 15, 1919, is a good example.

This expansion, and even torn structure, may be assigned to other causes than movement through a resisting medium, and the effect of such a medium would be to produce a strongly negatively accelerated motion.

Another fact of observation may be taken from the deflection of starlight through the corona. If such a deflection were produced it would cause the star to shift its position away from the limb of the sun in the same manner as Einstein's theory predicts. The plates taken by Eddington and Cottingham at Principe, and by Crommelin and Davidson at Sobral on May 29, 1919, show such shifts, uniformly greater than Einstein's theory predicts, with the exception of 2 cases out of 7.

The mean line which Dyson[20] adopts, in the discussion of the measures, gives a difference of 0".12 for a distance of a radius from the limb. This outstanding excess or a part of it, if real, may be interpreted as refraction, if Einstein's theoretical value of the shift be accepted. Even if this result could be confirmed, we would be at loss for a means of making an application of it, since the properties of the coronal gases and the law of refraction obtaining there are unknown.

Some evidence may be taken from the passage of comets through the corona. Several remarkable cases are on record, as may be seen from the following table:

TABLE XII

Comet	Distance from Sun's Surface at Perihelion	Comet	Distance from Sun's Surface at Perihelion
	km		km
1680. .	231,300	1882 III....	530,300
1843 I.. .	126,700	1887 I.....	111,700
1880 I.....	186,500		

All these distances are less than the maximum observed height of eruptive prominences.

Observers of these comets could detect no physical changes which might be attributed to passage through the corona. The comet of 1882 split up, it is true, the nucleus dividing into a number of parts and a portion of the body becoming two separate attendants, but the phenomenon occurred on October 3, sixteen days after passage through the corona. The brilliancy of the comet was so great that it was observed almost without interruption throughout this period. From this we must conclude that the coronal atmosphere has no observable effect on the matter in the region of the nucleus of a comet, when the latter is moving through it at the rate of 500 km/sec.

Altogether the evidence points to a very low density, but further than that it does not tell us much.

Observational material on the densities of the prominences is quite lacking. About our only hope of securing such data seems to be from a study of the widths of the lines of the spectrum of the prominence by means of the spectro-interferometer. This would require a study in the laboratory of the effect of pressure on the width of lines in the spectrum of gases occurring in the prominences, and a study of the electrical and temperature effects. These lines would then be observed in the spectrum of prominences by means of a spectro-interferometer especially designed for the purpose. The pressures would then be obtained from curves determined in the laboratory. I hope to find means of carrying out studies of this kind.

Let us suppose that the coronal atmosphere is negligible so far as the prominences are concerned. Since the force cannot act continuously, let us suppose that the prominence is projected into space by a sort of explosive force acting for a short time. In order to produce uniform motion it will be necessary to neutralize the force-vectors on the prominence in some way. About the only forces opposing gravity in the region surrounding the sun, with which we are at all familiar, are light-pressure, electrostatic repulsion, and possible corpuscular bombardment. The inadequacy of light-pressure has already been shown. Let us see, then, what may be the character of an eruption generated by electrostatic repulsion.

If we accept the theory of Young that the photosphere is a surface of cloud, we may assign to it the properties of an electrical conductor. The amount of the positive charge which it may carry, due to the ejection of negative electrons, is difficult to estimate. This charge depends on the molecular agitation, short-wave radiation, and possible radium content of the sun. All things considered, the process of partition of the negatively charged electrons will go on until the forces ejecting them are balanced by the residual positive charge. However, the speed of ejection is so high, 17,000–150,000 km/sec., that for all practical purposes large numbers must escape the vicinity of the sun, leaving the photosphere essentially a positively charged sphere with respect to surrounding space.

[20] *Philosophical Transactions of the Royal Society* (London), **220**, 332, 1920.

Suppose, then, that the seat of the eruption lay on the sphere. The repulsive forces acting on the molecule of gas in a prominence would be given by[21]

$$F = \frac{Ee}{f^2} - \frac{ea^3(2f-a)}{f^3(f-a)^2}, \tag{16}$$

where

E = the charge on the sun
a = the radius of the sun
e = the charge on the molecule of the prominence
f = the distance of the molecule from the sun's center

If we let $d = f - a$ = the distance of the molecule from the sun's surface, then we have approximately

$$F = \frac{Ee}{a^2} - \frac{e^2}{4d^2} \tag{17}$$

when $\frac{f-a}{a}$ is small, i.e., the molecule is near the surface of the sun. From this we see that F is negative, i.e., that the force is attractive, unless

$$E > \frac{ea^2}{4d^2}. \tag{18}$$

This phenomenon is familiar to every experimenter. A pith ball is first attracted to a charged body by the induced charge on the near side. The ball will remain in contact with the charged body until separated a small distance, when it will fly away, repelled by the charge of contact. Since d is the only variable in the foregoing inequality, then there is a critical value for d for which

$$E = \frac{ea^2}{4d^2}. \tag{19}$$

At this distance the charged molecule will be suspended in unstable equilibrium. Beyond this point it will be repelled continuously, while for smaller values of d it will be attracted continuously toward the sun.

In the particular case of the sun, however, or in any sphere of considerable mass, the foregoing equation must be modified by inserting the gravitational vector. As applied to the sun, this equation of critical distance becomes

$$E = \frac{a^2}{e}\left[\frac{e^2}{4d^2} + mg\frac{a^2}{(a+d)^2}\right] \tag{20}$$

where m is the mass of the molecule and g is the value of superficial gravitation.

If we neglect other circumstances, then the value of d determined by this equation should be the height to which the most stable prominences rise and remain free from the chromosphere. If the sun's potential and that of all the prominences were constant, d would also be constant, but this is hardly to be expected, especially of e. For any particular prominence this leads directly to a relation between E and e.

A remarkable case of this sort was the prominence of October 13, 1919. This had the form of a detached arch, most of the material being concentrated near the crest. It remained unchanged, except in minor details, during seven and one-half hours of continuous observation, including 40 exposures and a number of visual observations. In this case $d = 120{,}000$ km, and putting the atomic mass of calcium at $66 \cdot 10^{-24}$ gm we have

$$E = 21.5e^2 = 62.7 \cdot 10^{-24}. \tag{21}$$

[21] J. J. Thomson, *Conduction of Electricity through Gases*, p. 14.

Several facts are apparent from equation (20). First, that electrostatic repulsion cannot ordinarily produce an ejection of matter without an additional starting force. Second, that the matter ejected can be in equilibrium only at one point — where d has the critical value. Hence, uniform motion cannot exist under these circumstances alone. Earnshaw[22] has proved the general theorem that an electrified body cannot be in stable equilibrium in an electric field under electric forces alone.

The electrical status of eruptive prominences is further embarrassed by the fact that there is no certain case on record where magnetic disturbances can be associated with the occurrence of an eruption, such as is often found in the appearance of a great spot. The outcome of the attempts to detect the Stark effect in the sun is awaited with interest.

Deslandres and Crookes have proposed the hypothesis of a cathode-ray bombardment to explain comets' tails and prominences. The high velocities of the cathode particles would make the force of repulsion follow the inverse square law from the origin of the particles on the sun's surface. This must be a purely local phenomenon or we should expect eruptive prominences to be the normal condition rather than the converse. We are, then, confronted again with an acceleration which does not agree with observation.

CONCLUSION

Such a simple law of motion, as has been found to obtain, cannot be expected to result from a complex relation of forces in every case, but, on the other hand, we should look for a simple condition to exist. I have shown that, in general, streamers and knots moving into spots and areas of attraction are subject to accelerated motion just as we might expect them to be, when attracted by a local force; and that the vertical component of velocity is only about one-third that which it would have under gravity alone, neglecting the force which is apparently causing the motion.

This suggests what is probably the simplest explanation of all, namely, that the gravitational attraction of the sun for the matter in the prominence is so modified as to have practically no effect. Whether this is due to loss of gravitational properties, or to a suspension by means at present unknown, is difficult to decide. It is evident, however, that the prominence is still under the influence of the magnetic and possible electric forces on the sun, as is indicated by the downpouring streamers, which send matter into the spots and areas of attraction in spite of the high velocity of the eruptive prominence itself.

There is also, often, some lateral motion of the prominence toward the principal point of attraction, as is shown by the movement of the prominence of May 29, 1919, of about 8° of latitude toward the spot. Evershed records a movement of 5° of latitude toward the area of attraction in the prominence of May 26, 1916.

The expulsion of the prominence and the changes in its velocity are probably due to a periodic force, acting for a short interval and with a violence which increases continuously. The evidence on this point is contained in Table XIII, in which are tabulated all the eruptive prominences which show more than one impulse. Of the nine cases, six show continuously increasing values of the change of velocity (ΔV) due to the impulse. The last three show slightly decreasing values.

Since the prominence is moving with uniform motion, ΔV is proportional to the force applied, and the time during which it acts, if the mass remains constant. If the repelling force is one which varies with the reciprocal of the distance or a power of this greater than unity, then for every case in Table XIII the force is always increasing at successive impulses.

Nearly any periodic force capable of repelling gas molecules would satisfy these conditions. Probably the periodic ejection of showers of electrons from a disturbed area in the photosphere would satisfy the conditions. The high velocities of these bodies would cause them to yield their energy to a number of gaseous atoms before they were brought to rest by attaching themselves to one of the atoms higher up in the prominence, thus distributing the repulsive force throughout its mass. The speed (17,000–150,000 km/sec.) would permit an electron to move from the bottom to the top of any prominence in a few seconds.

[22] Clerk Maxwell, *Electricity and Magnetism*, **1**, 174.

This ability to distribute its energy throughout the prominence might explain the fact that no certain changes of form of the prominence can be attributed to an impulse occurring between two exposures with the spectroheliograph. On the other hand, the velocities given to calcium atoms would, on the average, be much less than those attained by hydrogen. This might explain the more elongated, columnar form of some promi-

TABLE XIII

Plot No.	Prominence	Height in 1000 km	V	ΔV
			km sec.	km sec. sec
13	Fényi Sept. 6, 1888		2.2	
		18	83.3	81.1
		63	175.5	92.2
22	Tacchini Nov. 16, 1892		4.4	
		126	6.6	2.2
		159	28.3	21.7
		228	57.2	28.9
		332	115.0	57.8
11	Hale and Ellerman March 25, 1895		49.0	
		217	119.0	70.0
		305	202.0	83.0
5	Lee Oct. 21, 1914		6.7	
		132	22.0	15.3
		189	42.8	20.8
1	Pettit May 29, 1919	150	5.5	5.5
		200	14.7	9.5
		319	27.9	13.2
		410	60.0	32.1
4	Lee Feb. 18, 1920		10.6	
		164	18.6	8.0
		350	41.7	23.1
7	Fox May 21, 1907		7.5	
		190	37.5	30.0
		287	64.2	26.7
6	Slocum March 25, 1910		6.1	
		68	31.4	25.3
		174	53.6	22.2
9	Evershed May 26, 1916		64.2	
		228	191.7	127.5
		500	216.6	124.9

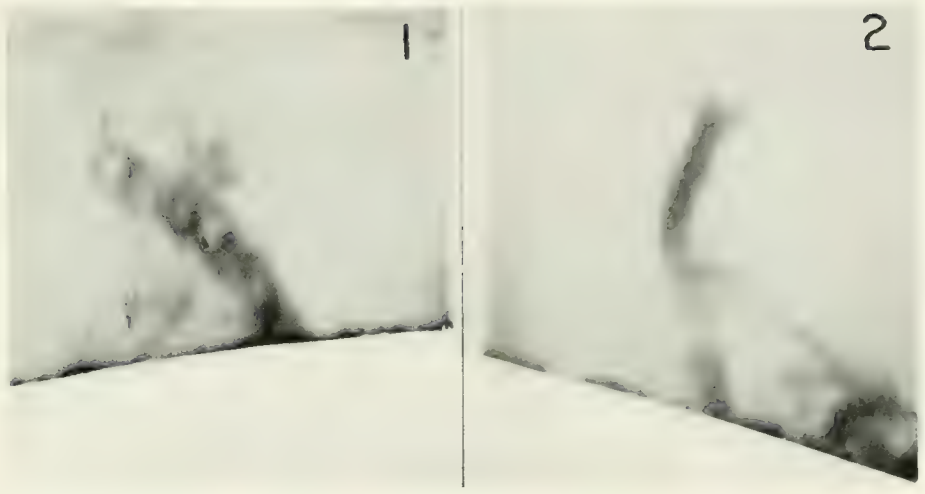
nences. Unfortunately, there is as yet no material available for a comparison of spectroheliograms of an eruptive prominence taken simultaneously in hydrogen and calcium lines. If its whole momentum were divided with a hydrogen atom whose mass is 1845 times as great, the electron would be capable of producing changes of velocity, greater than those observed, by a single impact.

There is at present no positive evidence of the existence of these periodic showers of electrons referred to above, and such a hypothesis must be considered as only a tentative possibility.

August, 1920

END OF VOLUME III

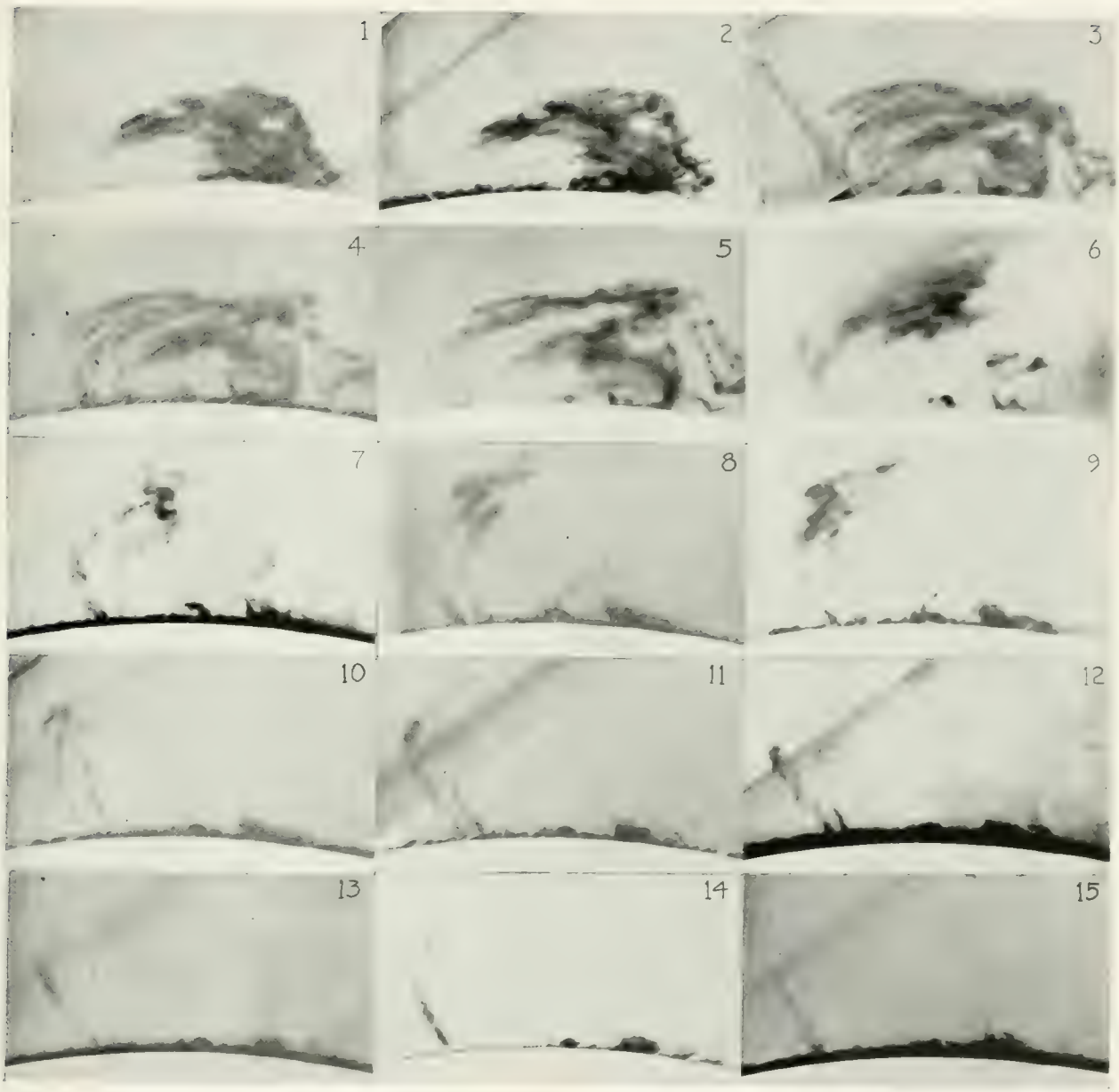
PLATE XXVII



TORNADO PROMINENCES

(1) October 15, 1910; (2) July 12, 1919

PLATE XXVIII

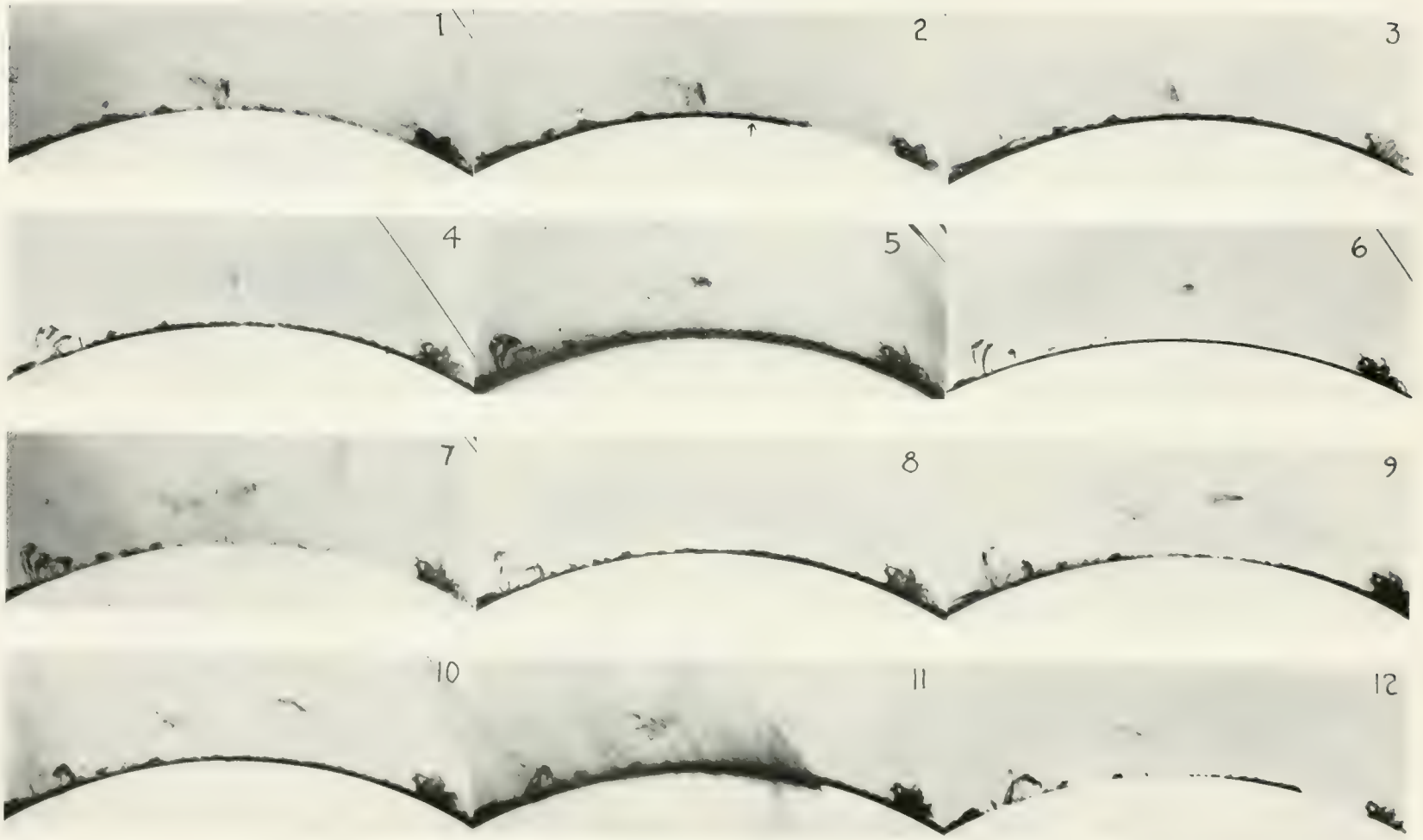


THE "SIGMA" PROMINENCE OF SEPTEMBER 23, 1919

The G.M.T. of exposures were as follows:

(1)4h50m40s	(2)4h55m40s	(3)6h00m52s	4 6h04m19s	(5) 6h12m45s
(6)6 34 07	(7)6 42 32	(8)6 52 05	(9)6 56 09	(10)7 00 19
(11)7 04 45	(12)7 09 05	(13)7 11 48	(14)7 17 30	(15)7 26 30

PLATE XXIX

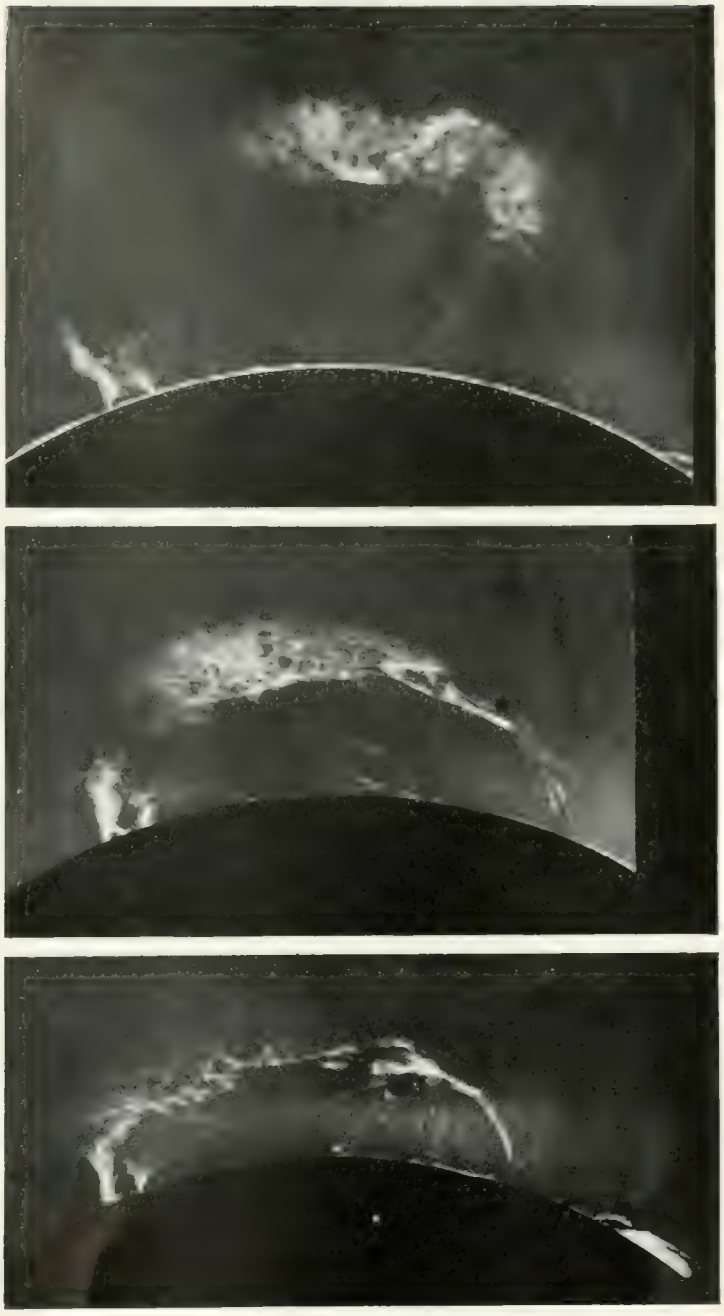


THE "ROCKET" PROMINENCE OF OCTOBER 6, 1919

The G.M.T. of the exposures were:

(1) 4h 15m 18s	(2) 4h 39m 21s	(3) 4h 57m 12s	(4) 6h 21 34s
(5) 6 39 27	(6) 6 45 16	(7) 6 57 05	(8) 7 07 05
(9) 7 16 02	(10) 7 30 26	(11) 7 41 53	(12) 8 09 14

PLATE XXX



c
G.M.T.
5h 32m 41s

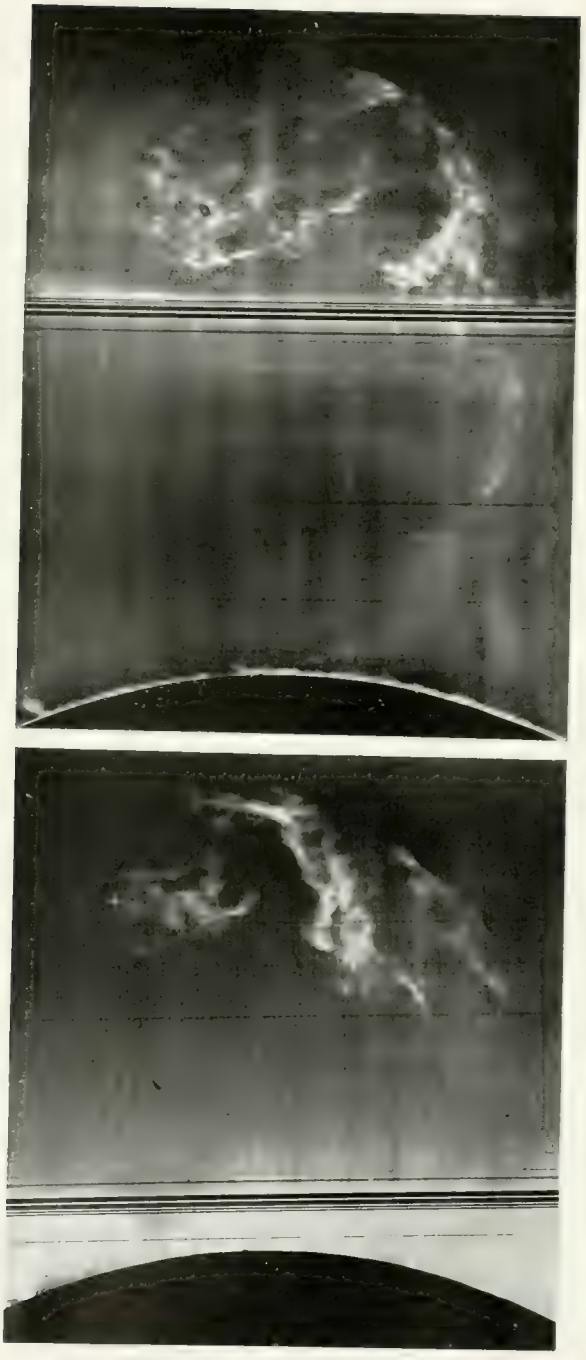
b
2h 56m 56s

a
1h 41m 10s

THE GREAT PROMINENCE OF MAY 29, 1919

Scale: for *a*, 1 mm = 0.320 km; for *b* and *c*, 1 mm = 8.410 km

PLATE XXXI



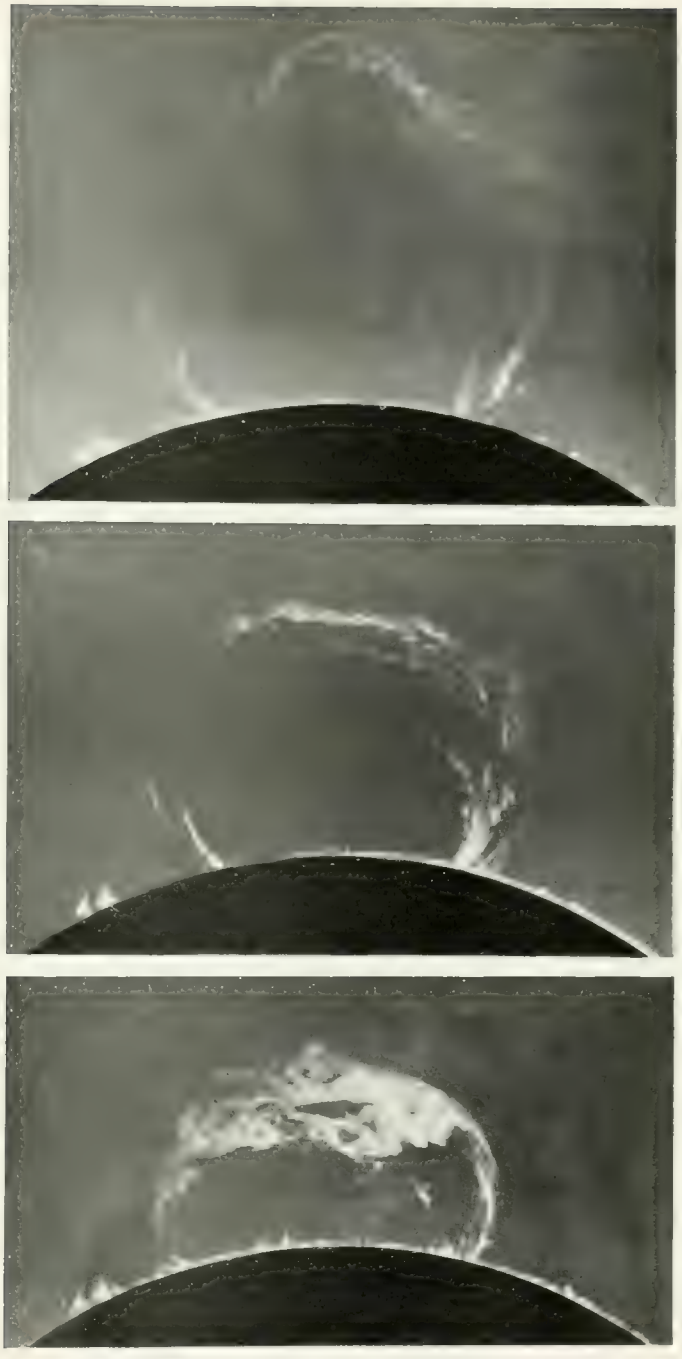
c
G.M.T.
$7^h57^m22^s$

d
$7^h10^m31^s$

THE GREAT PROMINENCE OF
MAY 29, 1919

Scale: 1 mm = 8416 km

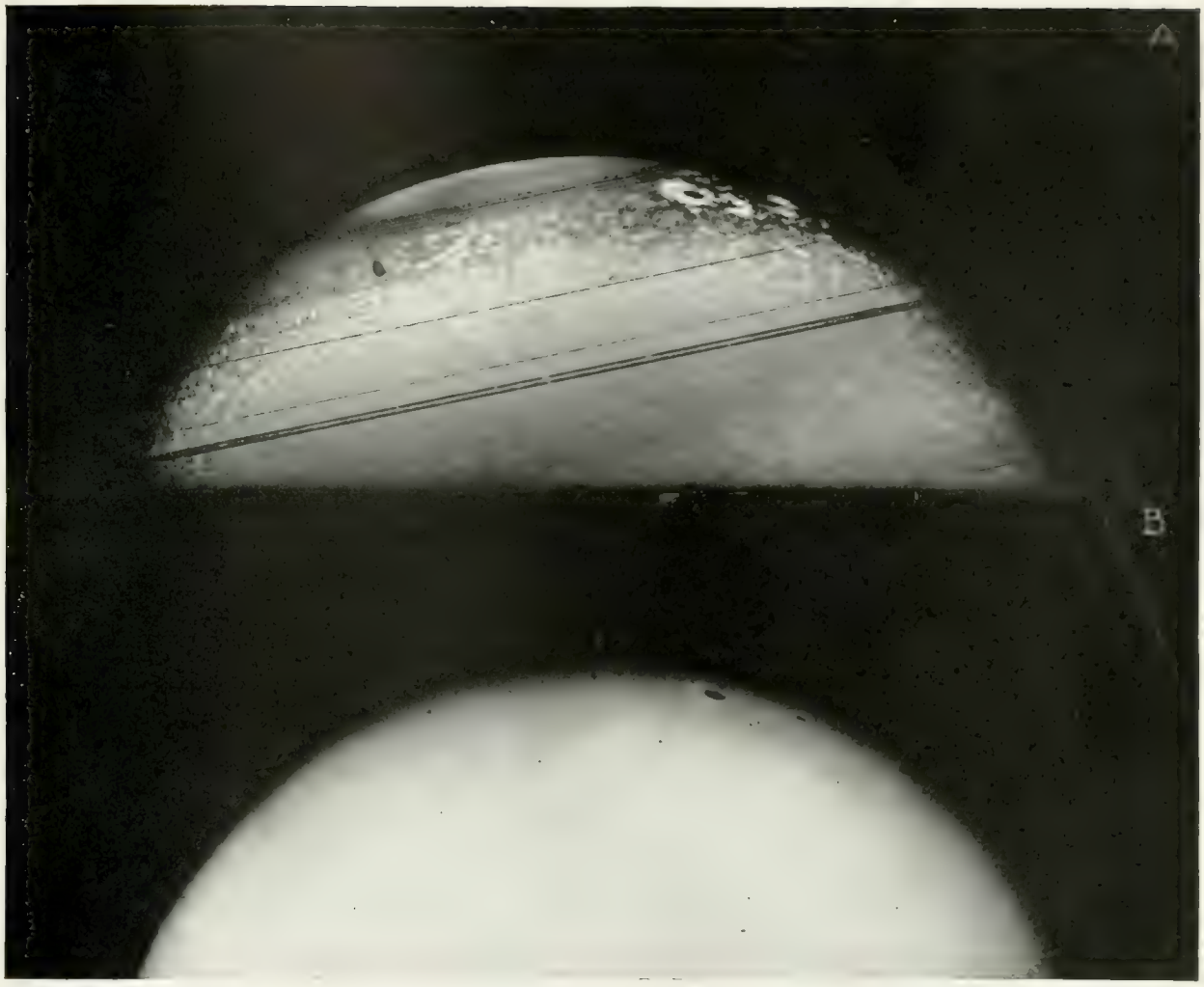
PLATE XXXII



THE PROMINENCE OF JULY 15, 1919

Scale: 1 mm = 9572 km

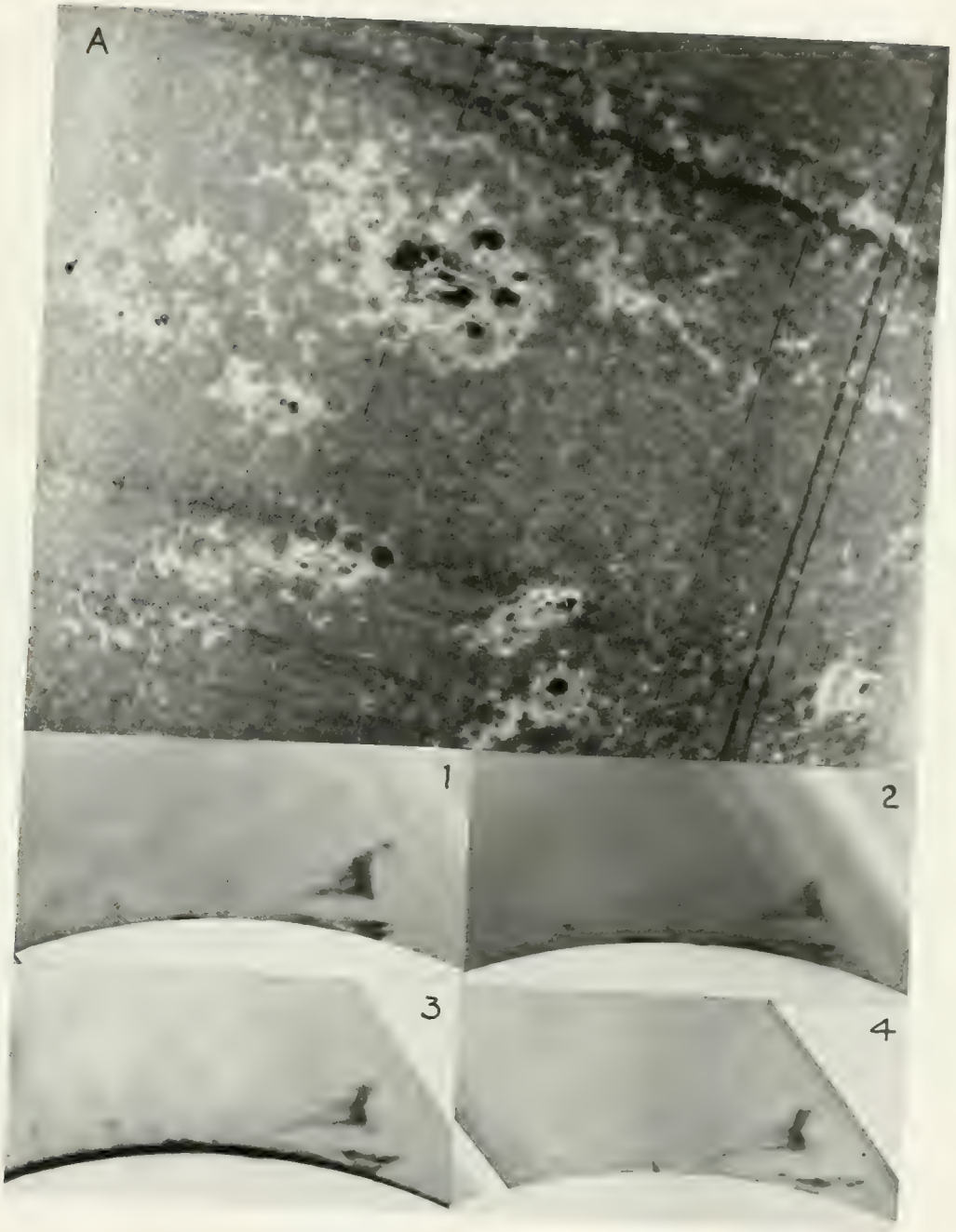
PLATE XXXIII



SUN-SPOT CONNECTED WITH THE GREAT ERUPTIVE PROMINENCE OF MAY 29, 1919, EXPOSURES MADE ON MAY 30

(*A*) Calcium spectroheliogram, (*B*) direct photograph

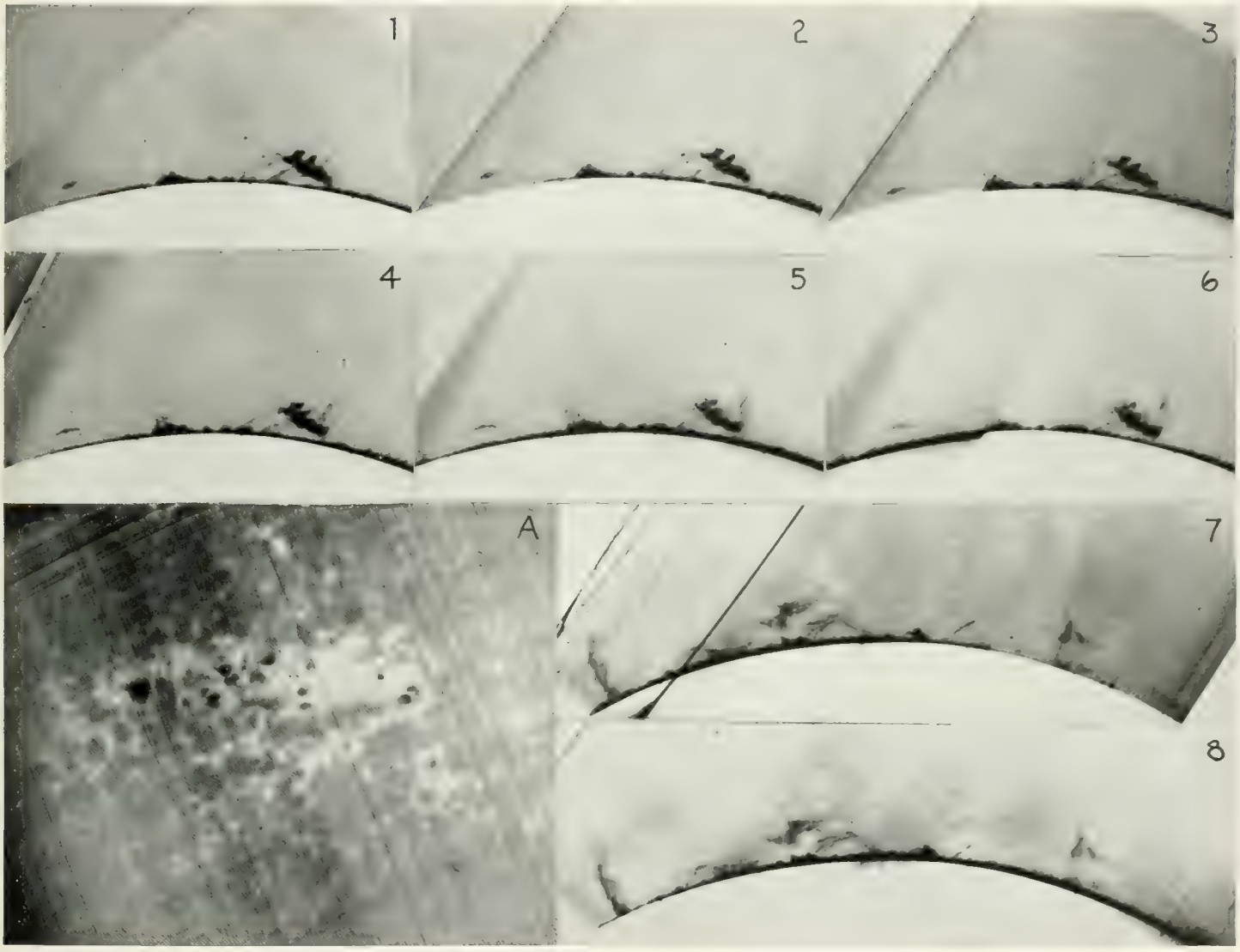
PLATE XXXIV



(A) CALCIUM SPECTROHELIOGRAM OF THE GREAT SUN-SPOT OF AUGUST 9, 1917

Scale, sun's diameter = 178 mm. Below are four exposures on the prominence which appeared over the spot when it came to the western limb of the sun on August 17, at G.M.T. (1) $4^h59^m37^s$, (2) $5^h01^m55^s$, (3) $5^h18^m20^s$, (4) $5^h25^m45^s$.

PLATE XXXV



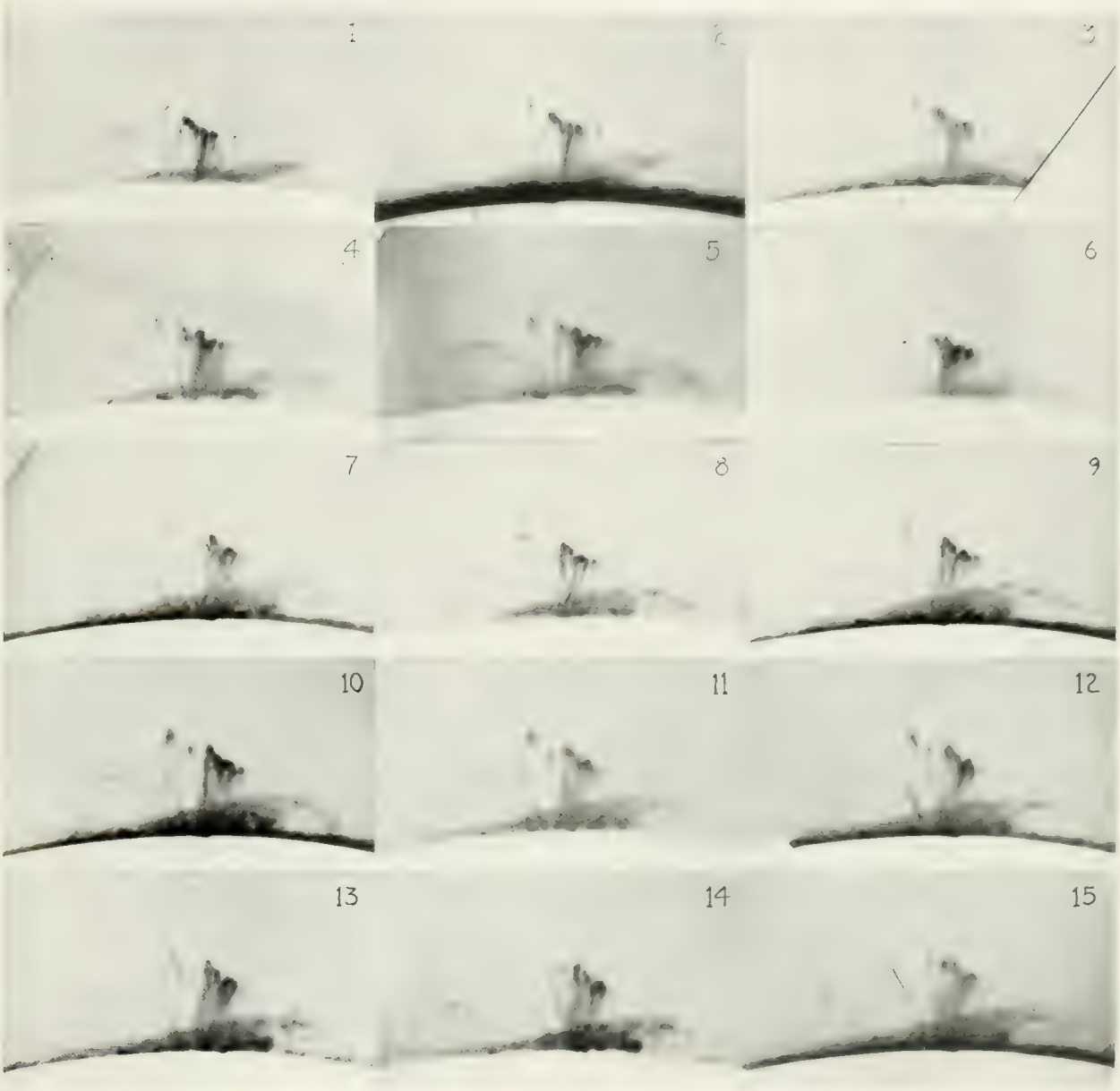
(A) CALCIUM SPECTROHELIOGRAM OF THE GREAT SPOT
OF MARCH 20, 1920

Scale, sun's diameter = 182 mm. Above are six exposures on the prominence which appeared over the spot when it came to the western limb on March 27 at the following G.M.T.:

(1) $5^h 28^m 46^s$ (2) $5^h 30^m 52^s$ (3) $5^h 33^m 50^s$ (4) $5^h 37^m 14^s$ (5) $5^h 40^m 15^s$ (6) $5^h 42^m 50^s$

Note the eruption from the suspended cloud. Below are given two exposures on a prominence over the same spot on March 29 at (7) $9^h 24^m 24^s$, (8) $9^h 28^m 15^s$.

PLATE XXXVI



PROMINENCE OF SEPTEMBER 22, 1919, WHICH APPEARED OVER A SPOT ON THE LIMB

The G.M.T. of the exposures were:

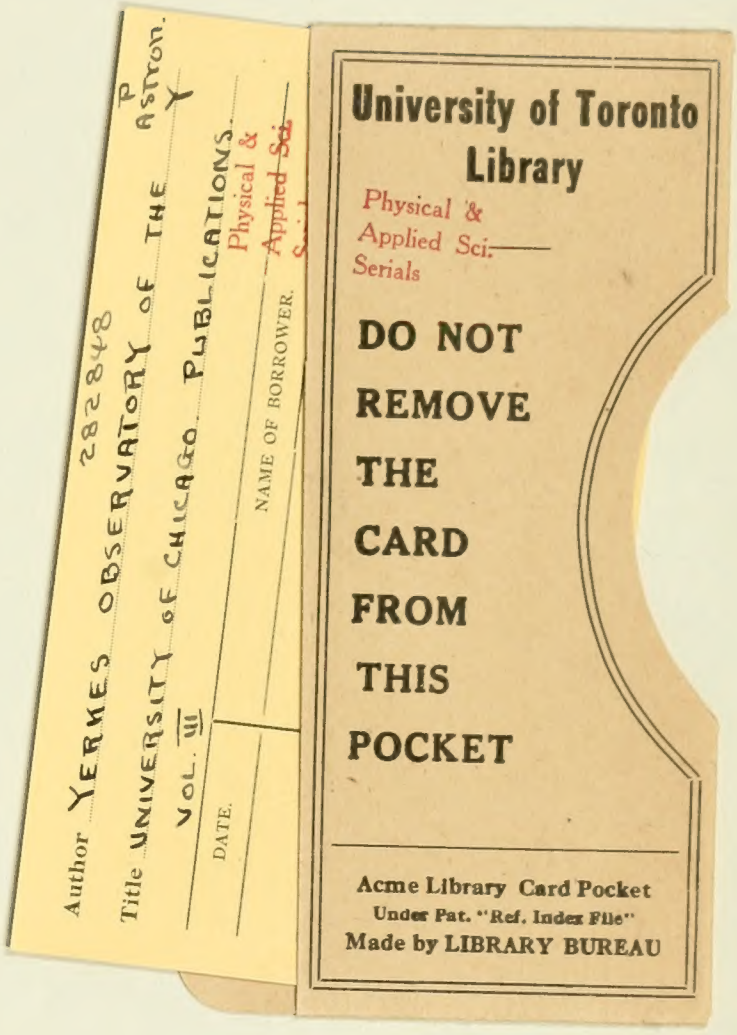
(1)$6^h33^m48^s$	(2)$6^h36^m09^s$	(3)$6^h37^m50^s$	(4)$6^h59^m38^s$	(5)$7^h04^m49^s$
(6)7 09 38	(7)7 14 38	(8)7 19 50	(9)7 24 46	(10)7 30 11
(11)7 34 46	(12)7 39 52	(13)7 44 45	(14)7 49 42	(15)7 54 50

PLATE XXXVII

PROMINENCE OF MAY 9, 1911

Exposures made at G.M.T. (1)$4^h45^m54^s$, (2)$4^h47^m06^s$

BINDING SLIP JAN 1 5 1933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